Blueprint Reading

Blueprint Reading

Prepared by

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and
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PREFACE

Blueprint Reading is written as a basic reference book for men whose duties require a knowledge of blueprint reading and layout work.

This book combines and supersedes Blueprint Reading and Layout Work and Use of Blueprints.

Beginning with a general discussion of the uses and kinds of blueprints, the text explains the language of a blueprint--lines, sections, symbols, dimensions, conventions, notes, and titles. Layout tools and geometry required, as well as procedures involved, are discussed. The sections on wiring and schematic diagrams are expanded in accordance with the increased training demands in electrical and electronic equipment and in order to acquaint operating personnel more rapidly with the symbolic notation now being standardized throughout the Armed Services.

This book is one of the basic Navy Training Courses and represents the joint endeavor of the Naval Air Technical Training Command and the Training Publications Section of the Bureau of Naval Personnel.

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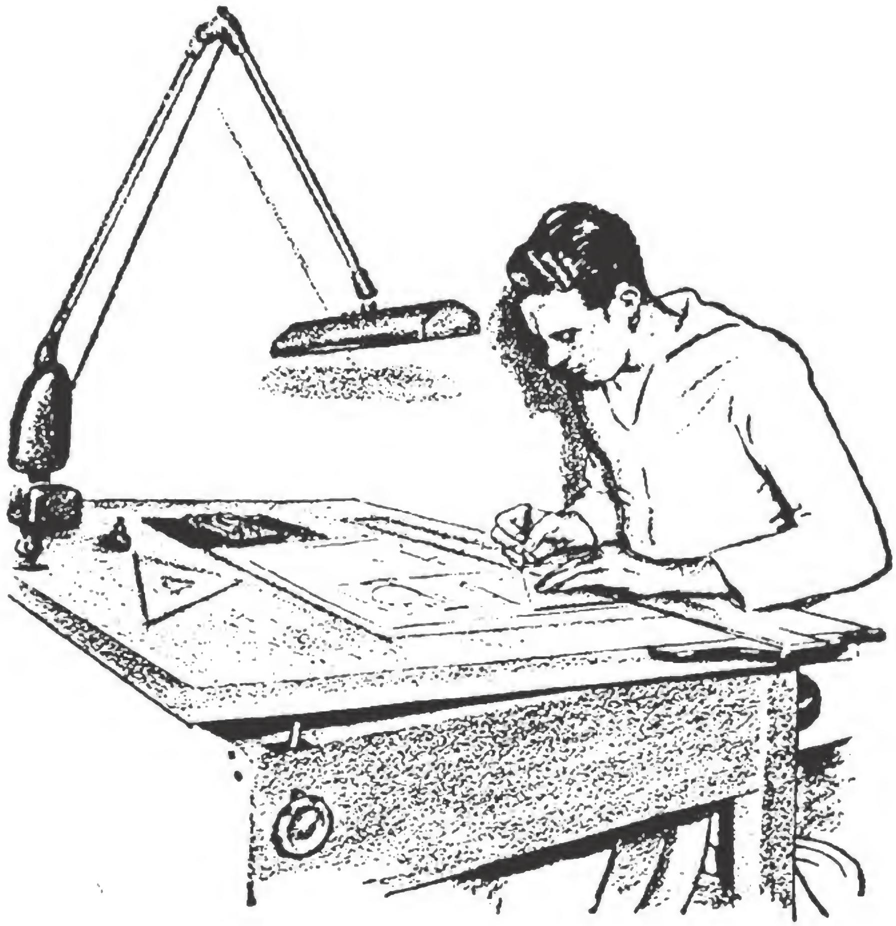

CHAPTER 1

MAKING AND HANDLING BLUEPRINTS

HOW ARE THEY MADE?

Blueprints are exact copies of mechanical or other types of drawings.

A mechanical drawing is one made with instruments such as compasses, rules, and dividers. Blueprints, or prints, as they are often called, are made from these drawings in much the same way that photographs are made from negatives.

The negative for the blueprint is known as a TRACING. It is made by placing a sheet of translucent tracing paper or cloth over the drawing. Everything on the drawing is traced on the tracing paper or cloth with black waterproof ink or a special black pencil. After the tracing is completed, it is checked, and the original drawing is filed for future use. Some drawings are made directly on the tracing material in pencil and then traced with ink or with the special black pencil.

Next, the tracing is placed on a sheet of clear glass mounted in a special frame. The tracing is covered with a sheet of sensitized light-green blueprint paper. The front of the frame is then exposed to a strong light, which penetrates the tracing at all parts not covered by lines and causes a chemical action on the print paper. There is no chemical action under the lines of the tracing because the black lines block off the light.

After proper exposure the print is removed and washed in clear water to remove the unexposed chemical. The exposed portions of the print paper turn a deep blue during the washing. The lines are white.

Any number of prints can be made from one tracing if it is handled carefully. When a large number of prints are required, they are made in a blueprinting machine, but the same principle is involved.

BLUEPRINT COLORS

Blueprints aren't always blue. All kinds of reproduced drawings are commonly referred to as blueprints or just prints. They may be white, brown, black, gray, or other colors. The differences lie in the kinds of papers used and in the development processes.

BLACK-AND-WHITE PRINTS have black lines on white background.

AMMONIA PRINTS, or ozalids, have black, maroon, purple, or blue lines on white background.

VAN DYKES have white lines on dark brown background.

NEGATIVE PHOTOSTATS have white lines on dark gray background.

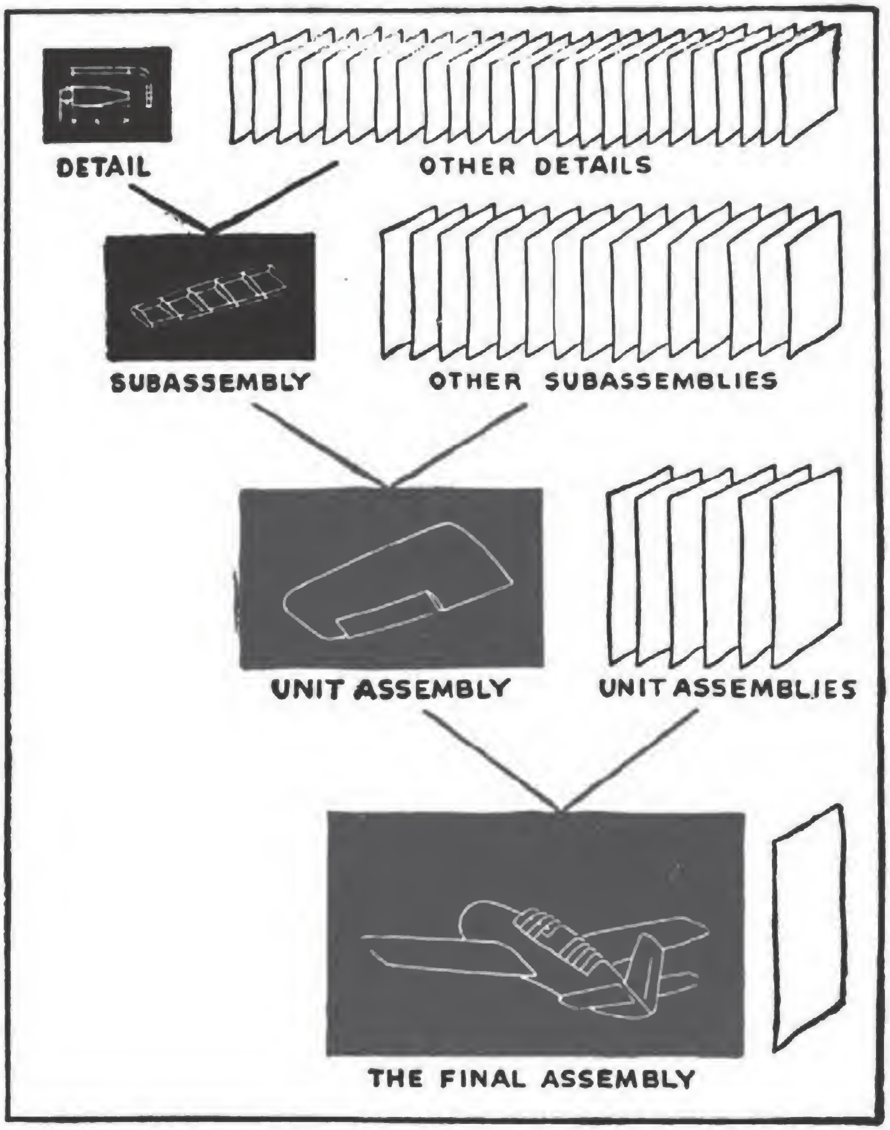

Figure 1-1.—Every part, every assembly has its descriptive print.

TYPES OF BLUEPRINTS

Look at figure 1-1. Notice that the assembling begins with a DETAIL BLUEPRINT of the aileron rib. Then there's a SUBASSEMBLY BLUEPRINT. That shows how the aileron rib joins the other parts of the aileron assembly. Next is a UNIT ASSEMBLY BLUEPRINT. From it you can tell

where the aileron joins the other parts of the wing assembly. The FINAL ASSEMBLY BLUEPRINT shows the entire wing assembly in relation to the completed plane.

When you are required to make a certain part you will use a DETAIL PRINT. This print will give you all the information you need to make a new part or piece. A detail sheet will show one large part or several small parts. It shows size, shape, kind of material, and method of finishing.

Remember that PLAN VIEWS serve as maps, that ASSEMBLY and SUBASSEMBLY PRINTS show how parts fit together, and that DETAIL PRINTS show everything needed to make a certain part or piece.

A drawing of an electrical circuit is called a SCHEMATIC. A schematic is laid out so that the electrical relationship among all the units is clear and readable. It is used for trouble shooting or tracking down the source of trouble that occurs within the circuit itself.

A WIRING DIAGRAM may or may not show all the elements of an electrical circuit, but it does indicate all the connections necessary for wiring the units together. It is, in a sense, an assembly diagram of all the parts that make up an electrical system.

HANDLE WITH CARE

Blueprints are not just scraps of paper. They are valuable permanent records and can be used again and again if you take care of them. Here are a few simple rules for getting the best results from them:

1. Keep them out of strong sunlight—they might fade.

2. Don't allow them to get wet or grease-smudged.

3. Don't make pencil or crayon notations on a print without proper authority. If you should get instructions to mark a blueprint, use a yellow pencil. Ordinary (black lead) pencil marks are hard to see on a colored background.

4. Never measure distance on a blueprint. If you can't find a dimension on one view, look at another view. If

you still can't find it, ask someone who knows. Why not measure? Because the original mechanical drawings might not have been drawn exactly to scale, or the print may have shrunk or stretched.

5. Keep your blueprints stowed in their proper place so that they can be readily located the next time you want to refer to them.

FOLDING BLUEPRINTS

A standardized, accurate system of filing blueprints is necessary in order that the prints may be found quickly. To expedite the locating of blueprints, the Navy (and the other Services) has a standard method of folding blueprints. This insures that the identifying marks always appear in the same place, preferably at the top when the prints are in vertical filing order.

Most of the prints you will use will already be properly folded. Your only concern will be to see that they are

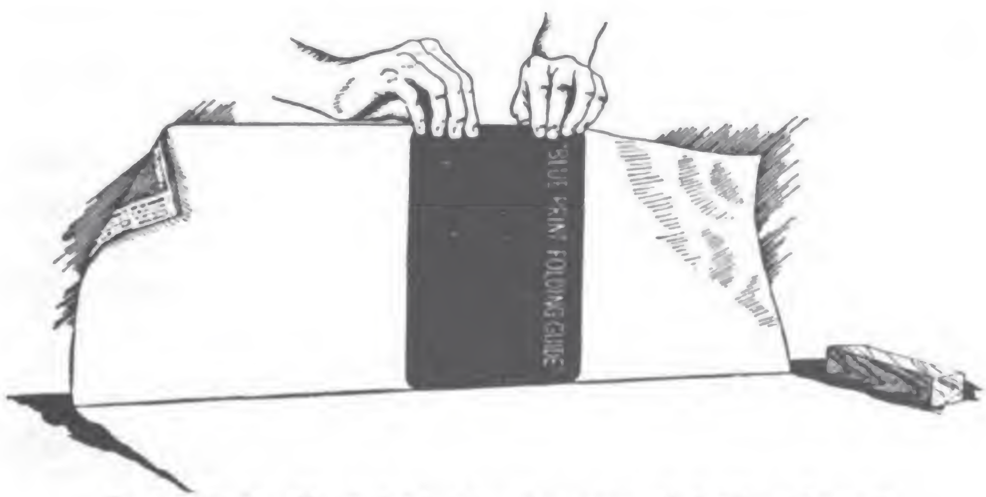

Figure 1-2.—First fold, showing use of folding board.

refolded correctly. However, you may have occasion to use prints that have not been folded at all or that have been folded improperly. Such blueprints should be folded according to the following instructions:

1. All blueprints should be folded neatly, in such a manner that the duplicate drawing number appears on

the outside in the upper right-hand corner of the print. The fold size should be approximately $8\frac{1}{2}$ inches by 11 inches (standard business letter size). The so-called "accordion-pleated form," with vertical folds as shown in figures 1–2 and 1–3, should be used.

Figure 1–3.—Successive folds, like the first, measure 11 inches. The last fold may be less than 11 inches.

2. A folding board is required for folding blueprints to the standard $8\frac{1}{2}$ inches by 11 inches. This board, of sheet metal, plastic, or plywood, should be $8\frac{3}{8}$ inches by $10\frac{7}{8}$ inches and should have its corners rounded.

3. A creasing device, that is, a smooth block of wood, metal, or plastic, or a glass paperweight, should be used to press the folds into LIGHT creases. (See fig. 1–4.)

4. On the following sizes of blueprints straight folds or no folds will be used as indicated:

Size in Inches	Type of Fold
$8\frac{1}{2}$ x 11	Blueprint already desired size. No fold required.
11 x 17	Fold once to $8\frac{1}{2}$ x 11 inches.
17 x 22	First fold to 17 x 11, then to $8\frac{1}{2}$ x 11 inches.
22 x 34	First fold to 34 x 11, next to 11 x 17, then to 11 x $8\frac{1}{2}$ inches.
11 x 34	First fold to 11 x 17, then to $8\frac{1}{2}$ x 11 inches.

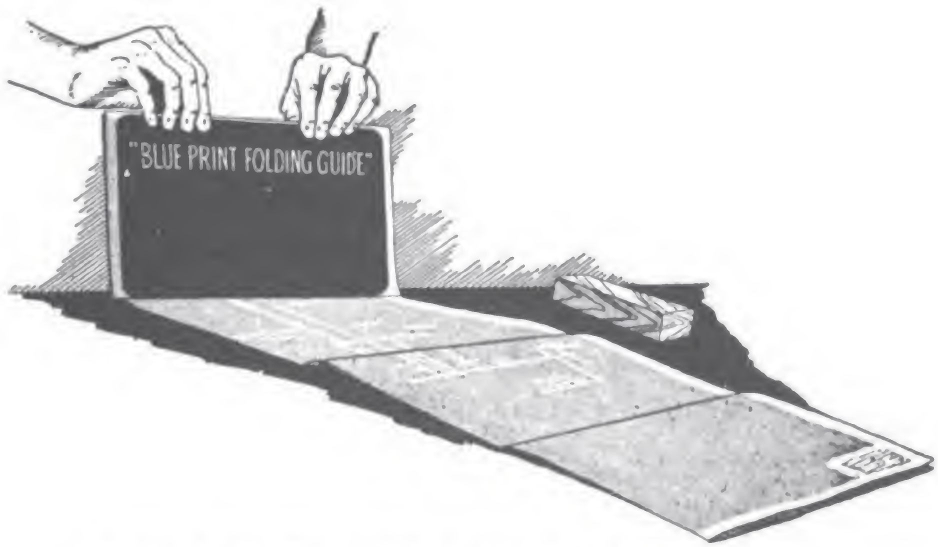

Figure 1–4.—The width is folded in $8\frac{1}{2}$-inch folds.

5. On all roll-size blueprints (that is, on all prints except those of the sizes listed above) the accordion fold is made by use of the folding board. In each case the first fold (fig. 1–2) is made from the end that carries the drawing number, and it is an 11-inch fold. Each fold thereafter (fig. 1–3) is 11 inches, except the last, which in some cases may be less. After the LENGTH of the print has been folded down into the required number of 11-inch accordion folds, the WIDTH is folded in $8\frac{1}{2}$-inch folds. (See fig. 1–4.) These may be rolled or straight folds.

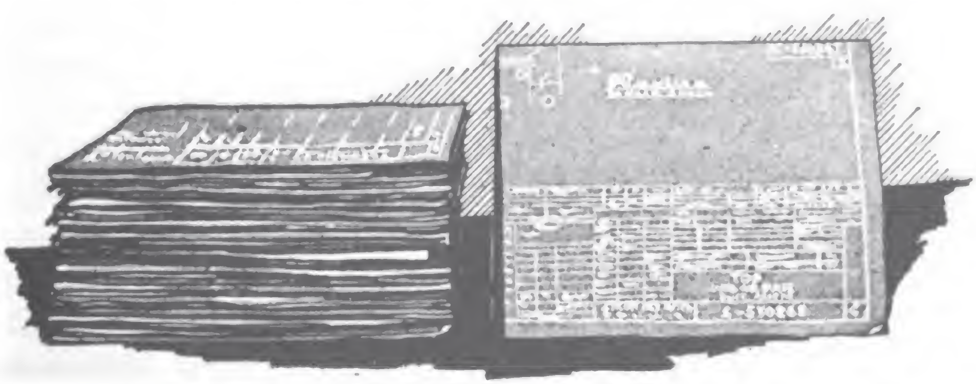

Figure 1–5.—Duplicate drawing number and change are shown in upper right-hand corner.

6. When the duplicate drawing number or numbering area fails to appear on the face of a print, all such prints should be folded face side or printed side in, so that the print number is on the underside of an outside fold and can be seen when you raise one corner of the blueprint. (See fig. 1-6.)

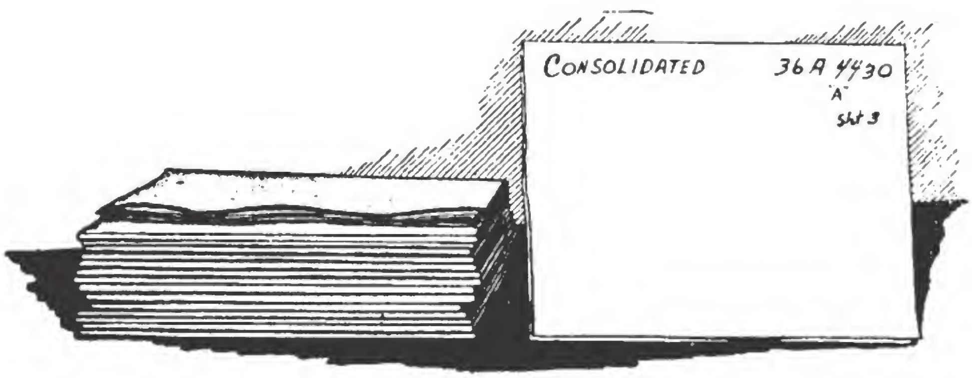

Figure 1-6.—Contractor's name provides further identification on a print.

7. Specifications for blueprints to be used by the Armed Forces require that the blueprints be so marked as to have the identifying information visible when the prints have been folded as prescribed in this section. However, some blueprints may be folded according to other procedures, depending on the usages of the manufacturer. In such cases the proper information should be marked or stamped on the print as necessary. (See fig. 1-6.)

QUIZ

1. Which blueprint would represent a later step in the construction of an object—a unit assembly or a subassembly?
2. Blueprints are used to save mechanical drawings. What kind of care must you exercise to save blueprints?
3. If a necessary line dimension were missing from your blueprint, why couldn't you just measure the line on the blueprint?

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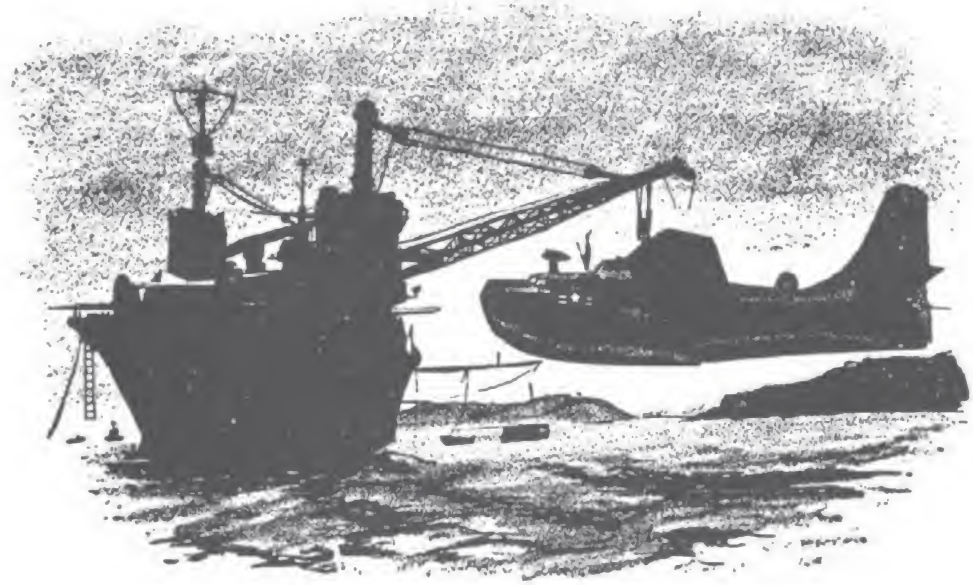


CHAPTER 2

BLUEPRINT VIEWS

PHOTOGRAPH OR BLUEPRINT?

A photograph of an object gives you a good idea of the shape of an object and the relationship of its various parts. It may show its exact size. The camera brings all visible parts into one picture view on one plane. It records pictures of objects much as your eyes see them. But the camera picture is deceptive, just as your eyes are deceptive.

Just recall the last time you looked down a straight stretch of railroad. Your eyes told you that the tracks came together at a distant point, but you knew the tracks were parallel, so you didn't believe your eyes. Because the camera records this deceptive appearance, photographs cannot be used where accurate blueprints are necessary. The lines on a photograph do not register directly the true length and shape.

Photographic blueprints are valuable visual aids when used to show general location, function, and appearance

Figure 2–1.—Exterior characteristics of .45-caliber automatic pistol.

of parts and assemblies. They are often used to show the special characteristics of parts, as in figure 2–1.

Operation steps are often shown by a series or sequence of photo prints. You may learn to take a mechanism apart and reassemble it by using photo prints as a guide.

EXPLODED VIEWS

Another valuable use of the photo is for exploded views that show locations of parts. Figure 2–2 shows two exploded views of the .45-caliber automatic pistol. Notice how the parts are spread out in line to show clearly each part's relationship to the other parts. These views are also known as TRAIN views.

PERSPECTIVES

Often it is desirable to have a picture of a new type of craft or machine before such an article has been manufactured. The draftsman can use his mechanical drawing tools to create these pictures. Figure 2–3 is an example of such a drawing.

These substitute pictures are called PERSPECTIVES. On a perspective, lines that are actually parallel would run together if extended. Perspectives are excellent substi-

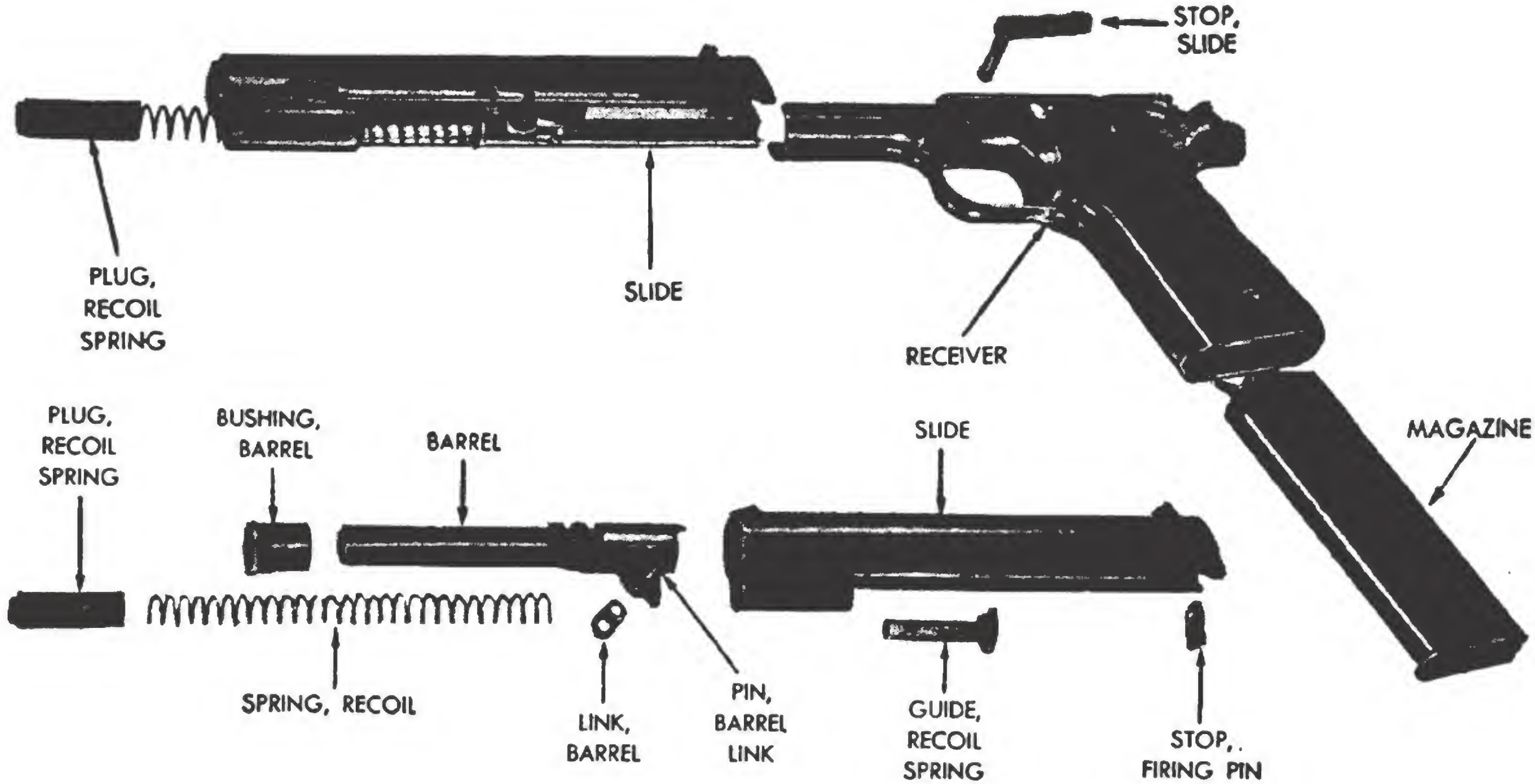


Figure 2-2.—Exploded, or train, views.

tutes for photographs and may be used in the same manner; but you will not use either of them for construction or repair blueprints.

In figure 2–3 notice the length of the left and right wings. They are actually the same length, but if you measure them on the picture, you will find one shorter than the other. In order to draw the airplane as it appears to the eye, the artist FORESHORTENED the wings.

Figure 2–3.—A perspective, like a photograph, does not give true lengths.

THE ISOMETRIC

The isometric is somewhat like the photograph and the perspective. All its lines representing horizontal and vertical lines on an object have true length. Vertical lines are shown in a vertical position, but lines representing horizontal lines are drawn at an angle of 30° with the horizontal. Vertical lines and lines representing horizontals are known as ISOMETRIC lines. In figure 2–3 all lines except *A* and *B* have true length because they are horizontal and vertical lines on the object. Lines *A* and *B* are not isometric lines, and their lengths are not true.

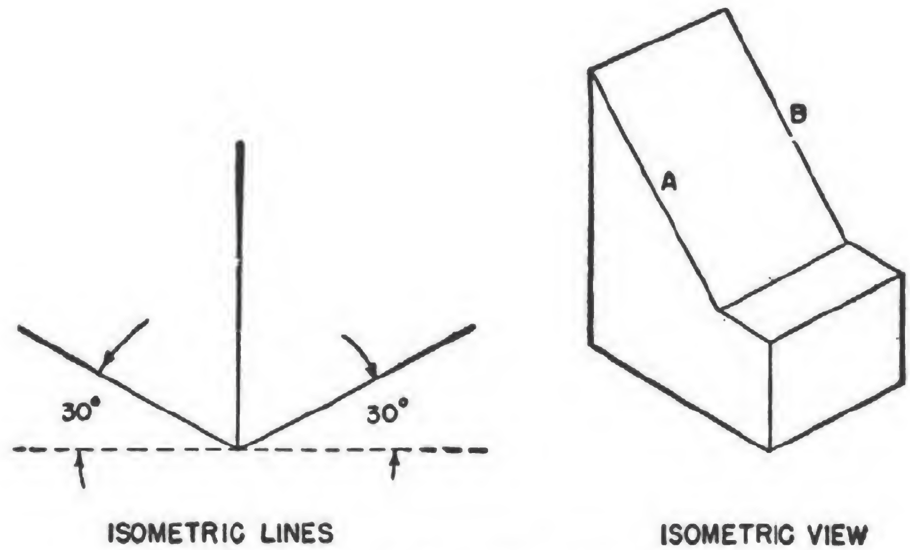


Figure 2-4.—Isometrics.

Isometrics have much the same use as other picture drawings. In addition, they may be dimensioned, and blueprints of these drawings may be used for making simple objects. But isometrics cannot be used alone for complicated parts or structures. They may be used as an aid in clarifying the accurate orthographic drawings that are the foundation of all construction blueprints.

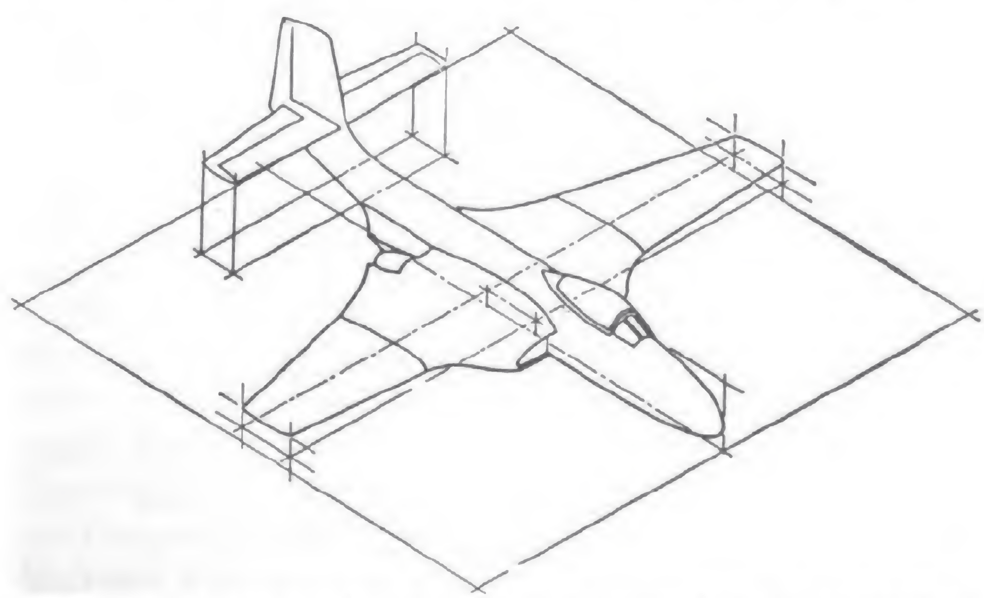


Figure 2-5.—An isometric view is the draftsman's trick for showing three views at once in dimension, but the object is distorted.

ORTHOGRAPHICS

Blueprints that furnish complete information for construction and repair present an object in its true proportions. Such prints are copies of mechanically drawn orthographic views. These views are accurate and indicate true shape and size.

When you study orthographics, look at one view at a time. To get a good idea of a PT boat, you must look at it from either port or starboard, then from dead ahead or astern, then from topside. By observing from many points you can obtain a clear understanding of the whole boat. This is the basic principle of orthographics.

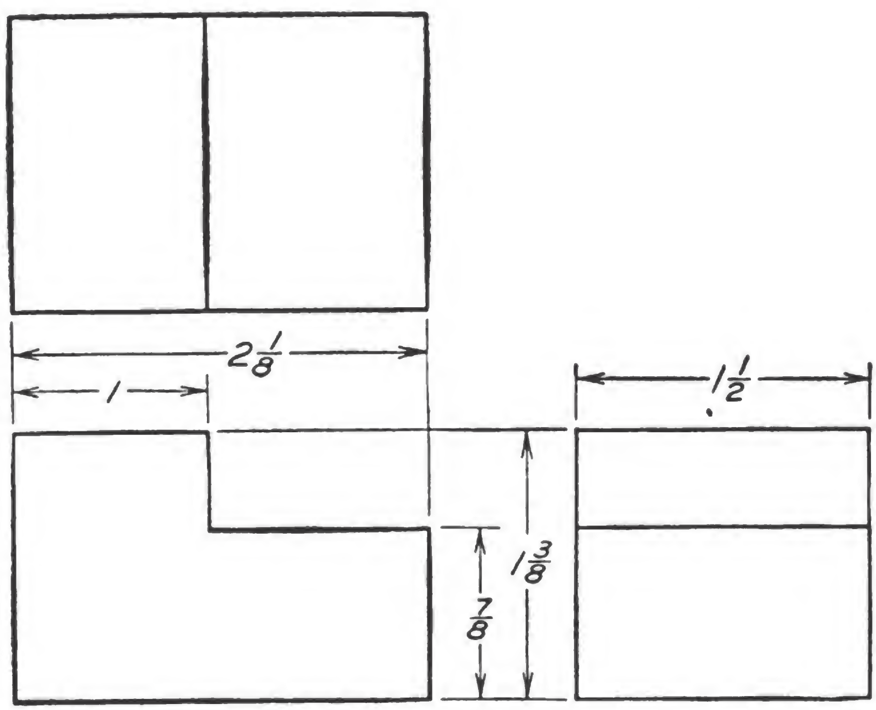


Figure 2-6.—The orthographic views.

You can see a surface of an object in its true shape and size only by looking directly at that surface. Your line of sight must be perpendicular to the surface at all points on the surface. Only then can you tell the true size and shape of each surface. When these views of the various surfaces are placed on paper, their proper

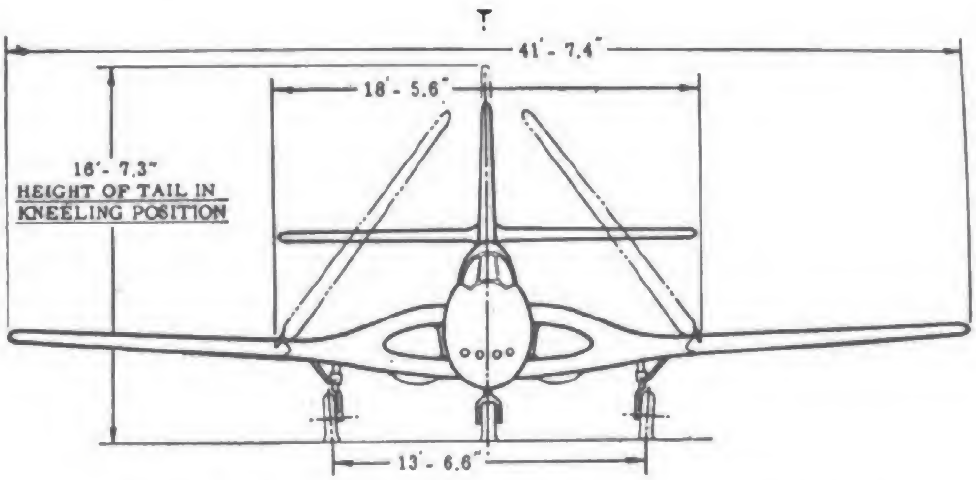


Figure 2-7.—An orthographic gives true views of an object's dimensions.

relationship is maintained by the proper arrangement of the views.

ORDERLY VIEW ARRANGEMENT

Study the arrangement of the three views in figure 2–6. The front view (lower left in figure 2–6) is the starting place. It was selected for the front view because it shows the most characteristic feature of the object—the notch.

The right side view is projected directly to the right of the front view. Some of the lines on the right side view lie along extensions of lines on the front view.

Notice that the top view is placed directly above the front view and that some of its lines lie along extensions of lines on the front view.

After you study each view, try to imagine or visualize the appearance of the object. If you have trouble, use the methods shown in figures 2–8 and 2–9.

Fold the sheet between the front and right side views. That will give you a rough idea of the shape of the object as it appears in three dimensions. Figure 2–10 shows how the views are "pulled" from the object.

Think of the object as being immovable, and pretend that you are moving around it. This will help you tc

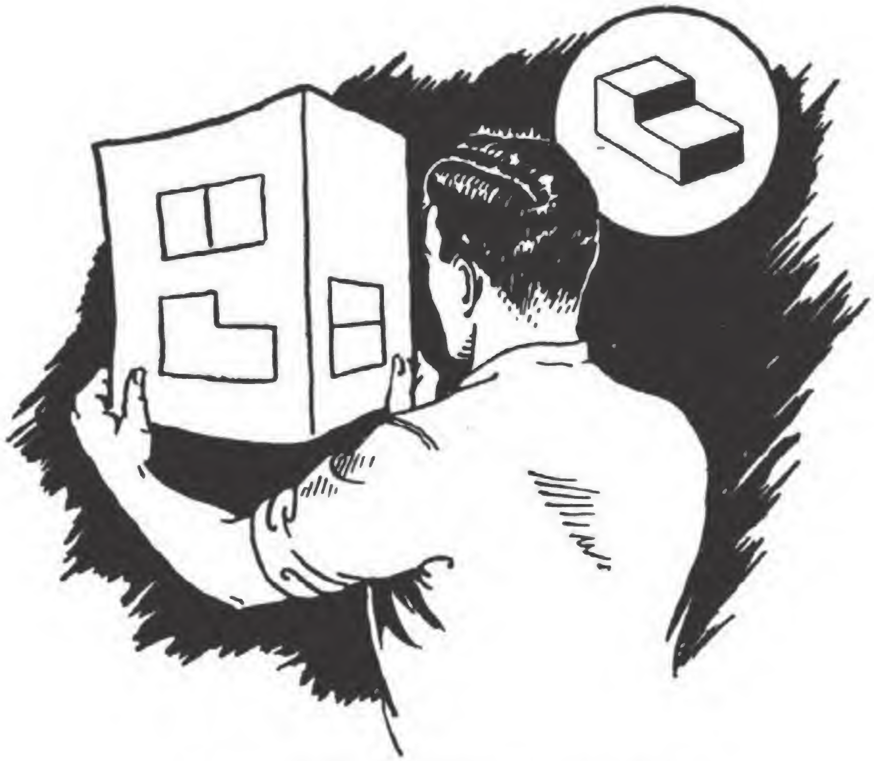


Figure 2-8.—Visualizing a blueprint.

Figure 2-9.—Compare the orthographic views with the model.

relate the blueprint views to the appearance of the object concerned.

AUXILIARY PROJECTION

Look directly at the front view of figure 2-11. Notice the inclined surface. Now look at the right side view and the top view. The inclined surface appears fore-

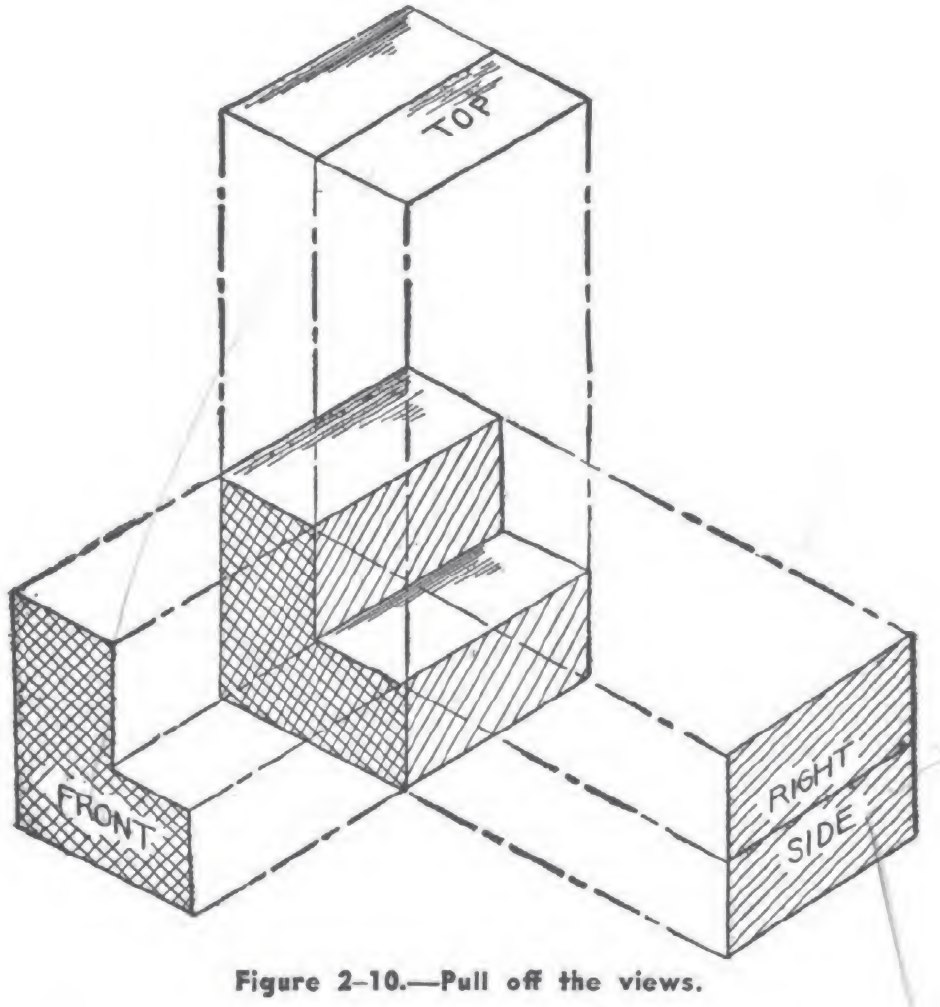


Figure 2–10.—Pull off the views.

shortened—not its true size. For a case like this the draftsman uses a special helping view, known as an AUXILIARY. It is obtained by looking directly at the inclined surface. This orthographic auxiliary provides a reliable view of an inclined surface. The principle of the auxiliary is shown in figure 2–12.

CURVED SURFACES

If you look at the front view, *a*, in figure 2–14, you can see that the object has a curved surface. If you look at the right side view, *b*, you'll see a triangle without any curve. The orthographic technique worked fine as long as you had a flat surface—but it is unable to show the curve of a curved surface.

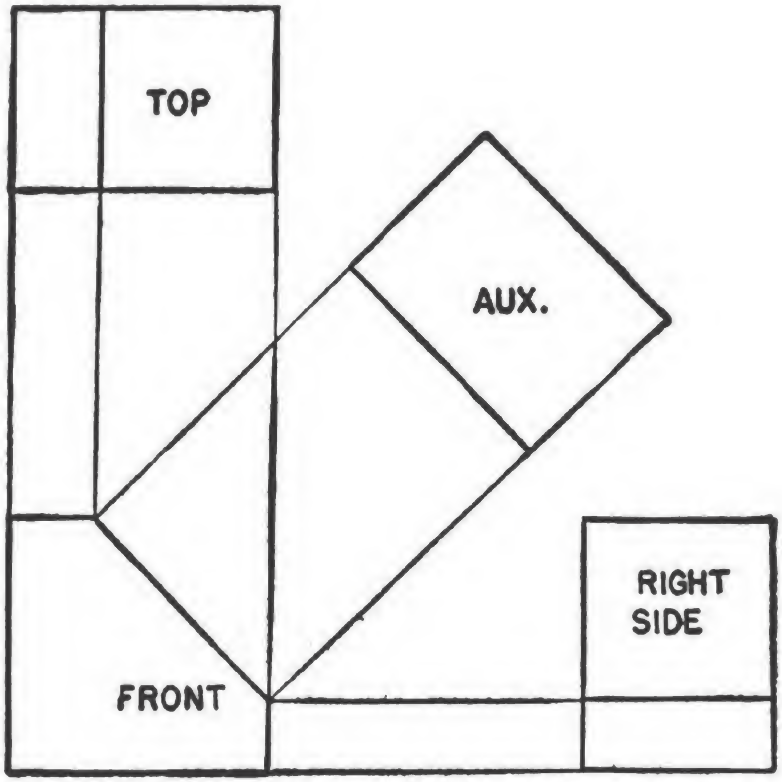


Figure 2-11.—Auxiliary view arrangement.

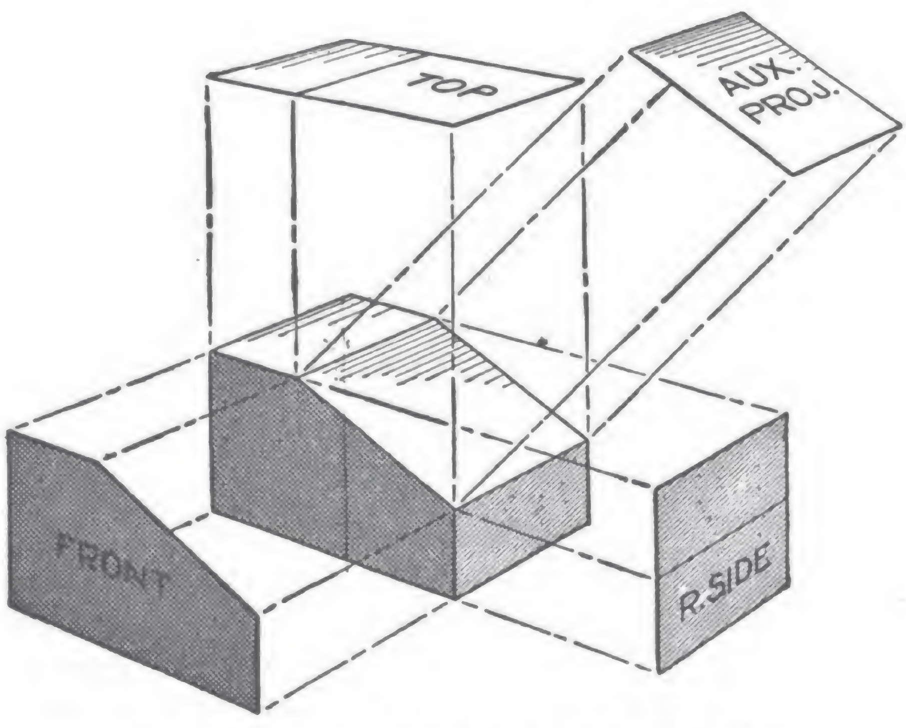


Figure 2-12.—Auxiliary projection principle.

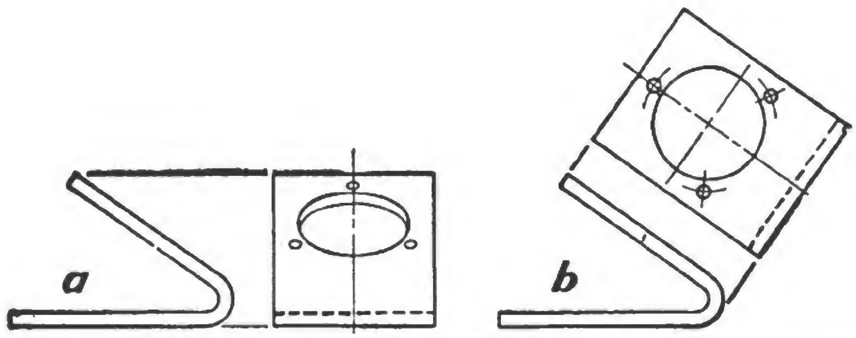


Figure 2–13.—Comparison of orthographic and auxiliary projection.

To make a cone like that shown in figure 2–14, you'll have to find the shape of the curved surface as it is laid out in the flat. You can find this shape by unrolling the cone. This calls for a DEVELOPMENT, and you will find information on this in chapter 11.

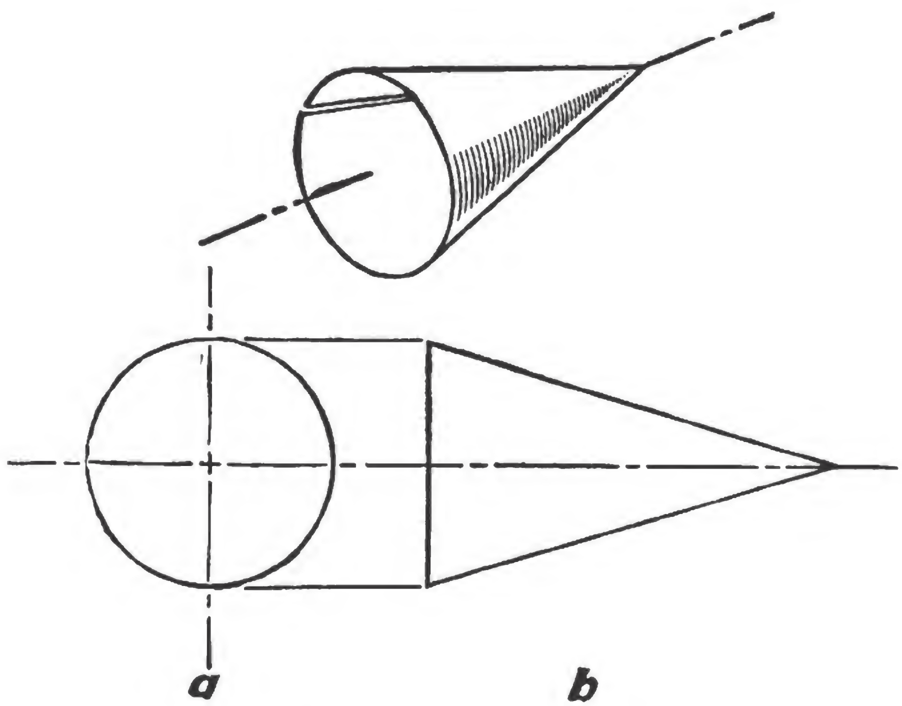
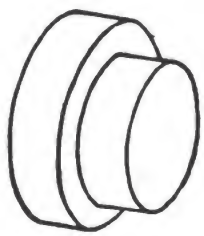


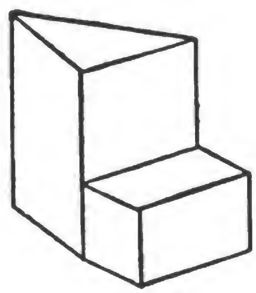
Figure 2–14.—Unroll the cone.

QUIZ

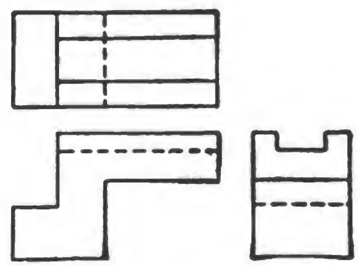
1. Why can't you use a photograph of an object as a blueprint when you make a replacement part for a machine?
2. What is another name for exploded views?
3. What lines of an isometric drawing are true in length?
4. When are mechanical perspectives used?
5. Why are orthographic drawings universally used as blueprints for construction?
6. What type of surface requires an auxiliary projection?
7. Sketch two orthographic views of A, three views of B, and an isometric of C.



A



B



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CHAPTER 3

LINES AND SECTIONS

DRAFTSMAN'S LANGUAGE

The draftsman's drawings are composed of lines of different construction, each line with a special meaning. Lines are indeed the "common words" of the draftsman—he draws his language. Because he must place a large amount of information in a small space, he uses as few words as possible.

The lines on drawings and blueprints are standardized. You need to learn the appearance and use of these lines to be able to understand blueprints.

LINE USE

A basketball court is laid out with lines—there are boundary lines, center circle lines, and free-throw lines. The basketball court is really a full-size, top-view orthographic made with lines. The lines may be of different lengths, widths, colors, and shapes for different uses. This same principle is used on mechanical drawings. On a blueprint the draftsman uses OUTLINE LINES. They

OUTLINE

correspond to the boundary lines of the basketball court. These heavy, solid lines represent the edges and surfaces that are visible from the angle at which the view is

drawn. You wouldn't be able to identify an object without the outline lines.

If you could look right through an object you would see other lines in the object and on the back surface. To represent these invisible lines the draftsman uses a medium-weight broken line. It is a series of short dashes, all of the same length.

HIDDEN LINE

These dashed lines are called HIDDEN LINES. They represent edges of surfaces behind the view which is represented by the regular outline lines. Both of these kinds of lines are shown in figure 3–1. Notice that these two types of lines form the backbone of the drawing.

ALTERNATE POSITION LINES show possible alternate positions of moving parts. The lever in figure 3–1 is shown in a right-hand position. But the alternate posi-

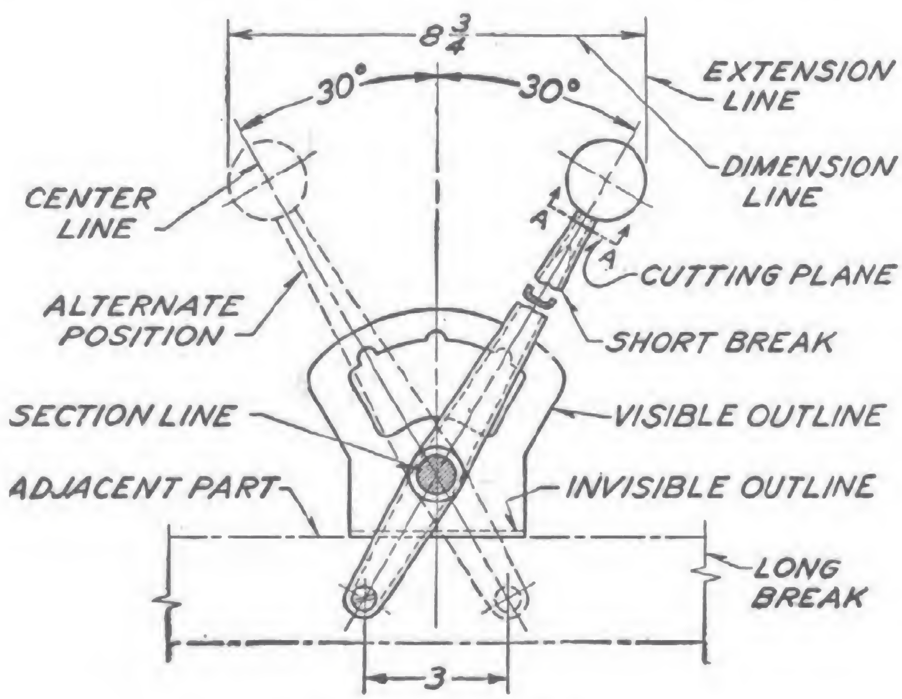


Figure 3–1.—Use of lines.

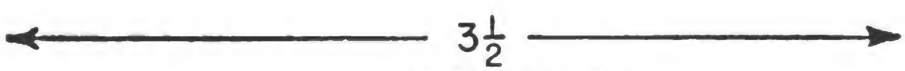
ALTERNATE POSITION LINE

tion lines tell you that it moves to the left, swinging through an arc of 60°. The dashes of this line are the same weight as hidden lines, but they are twice as long.

To locate the center of a circle or arc, CENTERLINES are used. They're also used to divide drawings into equal or symmetrical parts. You'll find these lines helpful in dimensioning and lining up views. Notice that the centerline is a lightweight line with alternate long and short dashes. Centerlines are always used to locate the center of a round hole.

CENTERLINE

Size is indicated on drawings by dimensions. Navy blueprints are usually dimensioned in inches. Size dimensions are placed in a break in the DIMENSION LINE. Some dimensions are placed between arrowhead tipped lines. In either case, the dimension distance is from the point of one arrowhead to the point of the other arrowhead.



DIMENSION LINE

To keep the dimensions clear of the view, they are placed outside the view. Sometimes it may be necessary to put dimensions inside the outline, but it's better practice to keep them outside. EXTENSION LINES, light in weight, extend from lines of the outline. They are started about one-sixteenth of an inch away from the view outline.

LEADERS

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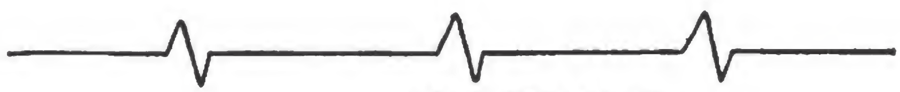
Notice how the different kinds of lines are labeled in figure 3–1. Each name is tied to the proper line by a LEADER. Either straight- or curved-line leaders may be used. A straight-line leader is usually slanted at an angle to the lines on the drawing. The pointing end of the leader is usually tipped with an arrowhead of one of the types shown. The note or name used with the leader is located in a clear space that is not covered by the views of the drawing or the dimension lines of the drawing.

Sometimes the draftsman is cramped for space. If he drew the whole object, he would either run off the paper or have undersize views. So he uses LONG BREAK LINES to tell you that he has shortened that part. The long break line is simply a space saver for the draftsman; it does not change the actual length indicated by the dimension.

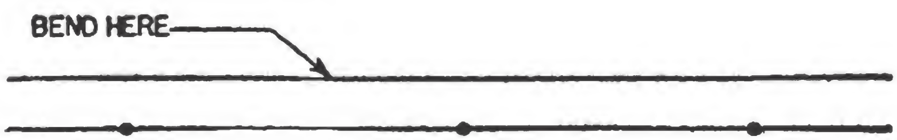


LONG BREAK LINE

SHORT BREAK LINES tell you that the draftsman has removed part of an outer surface to reveal the inside structure. (Notice the two short break lines in fig. 3–1.) You will find that short break lines usually come in pairs.

SHORT BREAK LINE

To indicate where thin metal is to be bent, the draftsman uses BEND LINES. Some draftsmen place dots on the line instead of the note "Bend here."



BEND LINES

COMPARATIVE WEIGHT OF LINES

Learn to distinguish lines by their weight, or width, which may be HEAVY, MEDIUM, or LIGHT. Figure 3–2 shows the weights of the lines you have learned in this chapter. Train your eyes to recognize instantly any kind of line.

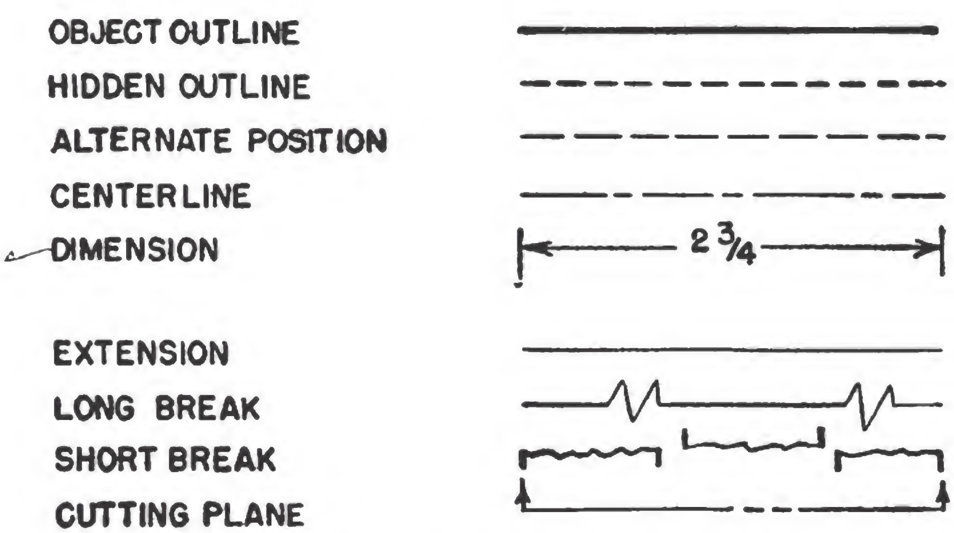


Figure 3–2.—Comparison of line weights.

INSIDE SECTIONS

When you first see a new type of boat, ship, or plane, you like to look inside to see how it's made. A SECTIONAL VIEW allows you to "look inside" an object shown on a blueprint. One of the views is shown just as if you had sawed out a section.

Notice the CUTTING PLANE LINE *AA* in figure 3–3*a*. It shows where the imaginary cut has been made. The isometric in figure 3–3*b* helps you to visualize the cutting plane. The arrows point in the direction in which you are to look at the sectional view.

Figure 3–3*c* is an isometric showing how you would see the object if it were actually cut in half.

The orthographic view of section *A-A*, figure 3–3*d*, is placed on the drawing instead of the confusing front

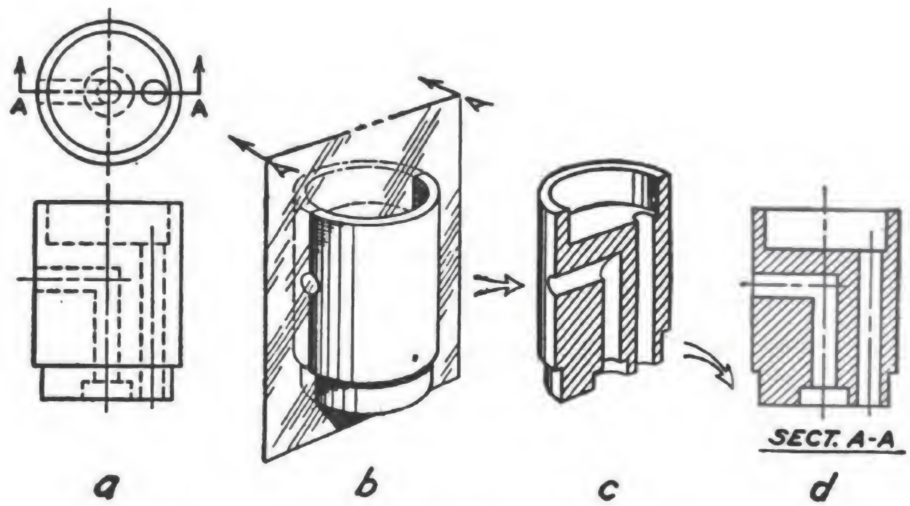


Figure 3-3.—Action of the cutting plane.

view in figure 3–3*a*. Notice how much easier it is to understand.

When sectional views are made, the part that is cut by the cutting plane is marked with diagonal, parallel SECTION LINES. The draftsman's word for the process of making these lines is CROSSHATCHING. When two or more parts are shown on one view, each part is sectioned or crosshatched with a different slant of line. Section views are necessary for a clear understanding of complicated parts. On simple drawings a section may serve the purpose of an additional view.

Section *A-A* in figure 3–3*d* is in FULL SECTION, because the object is cut completely through. You won't always see a full section. But there are other sections to help you to look inside. They are discussed in the next few pages.

OFFSET SECTION

In an OFFSET SECTION you have a joggle or offset in the cutting plane. The offset cutting plane in figure 3–4 is arranged so that the hole on the right side will be shown in section. The sectional view is the front view, and the top view shows the offset cutting plane line.

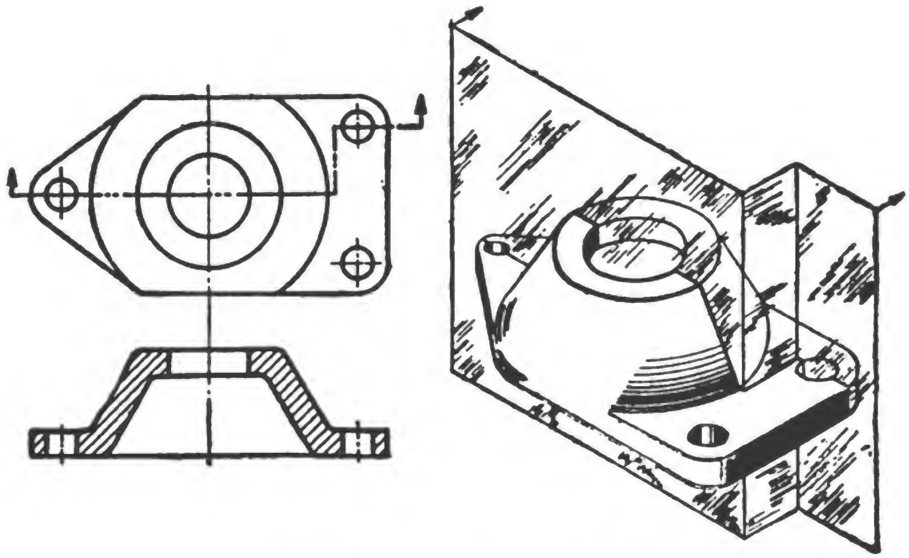


Figure 3-4.—Offset section.

HALF SECTION

Figure 3-5 shows a HALF SECTION. A half section is used when the object is symmetrical in both outside and inside details. One half of the object is sectioned; the outer half is shown as a standard view.

The object is round, and if you cut it into two equal parts and then divided those parts equally, you'd have four quarters. Now remove a quarter.

That's what the cutting plane has done in the perspective. It has taken a quarter of the cylinder away so that you can look inside. If the cutting plane had extended along the diameter of the cylinder, you would have been looking at a full section. But the cutting plane in this drawing extends the distance of the radius, or only half the distance of a full section. Hence it is called a half section, rather than a quarter section.

The draftsman has inserted an arrow to show your line of sight. What you see from that point is drawn as a half section in the orthographic view. The width of the orthographic view represents the diameter of the circle. One radius is shown as a half section; the other, as an external view.

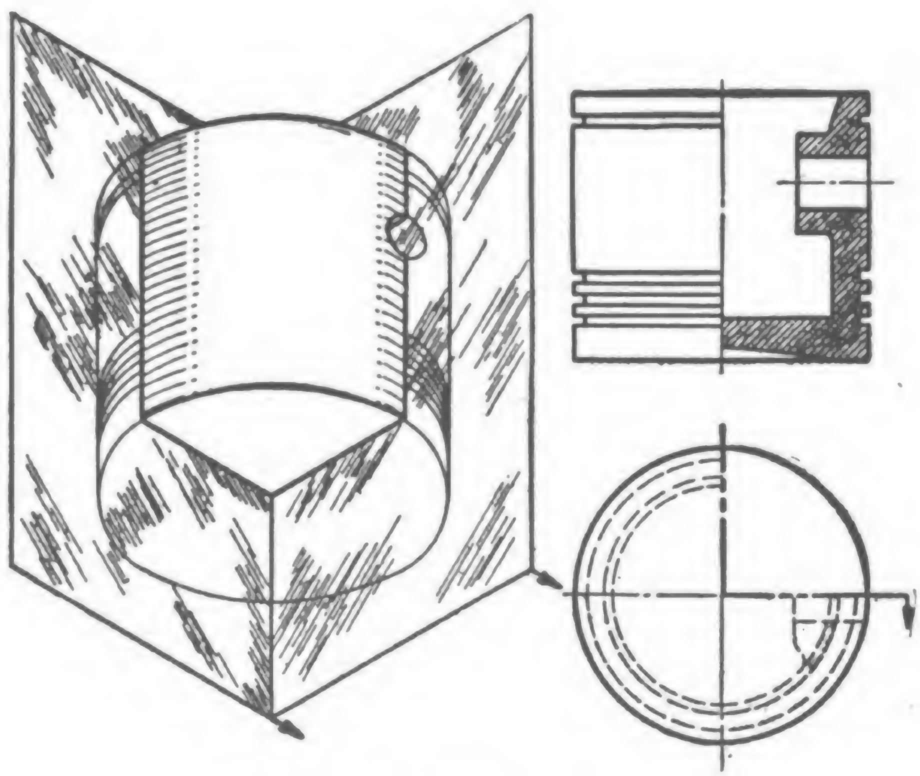


Figure 3-5.—Half section.

REVOLVED SECTION

To eliminate drawing extra views of rolled shapes, ribs, and similar forms, the draftsman uses a REVOLVED SECTION. It is really a drawing within a drawing, and it clearly describes the object's shape at a certain cross-section station or point.

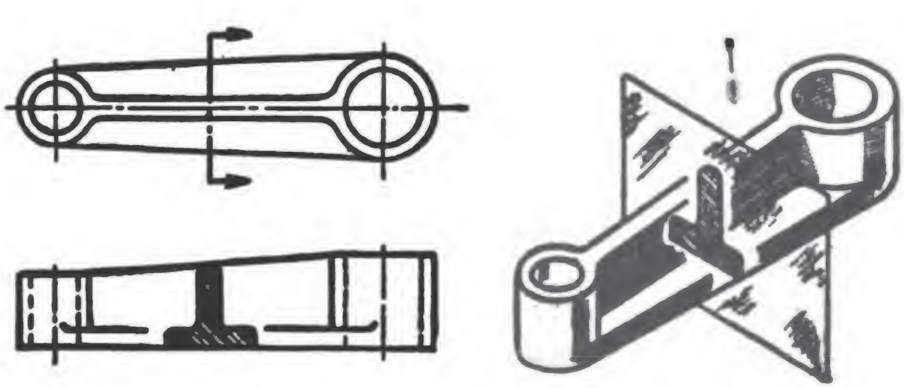


Figure 3-6.—Revolved section.

The draftsman has revolved the sectional view of the rib in figure 3–6, so that you can look at it head-on. Because of this revolving feature this kind of section is called a revolved section.

BROKEN-OUT SECTION

The inner structure of a small area may be shown by peeling back or removing the outside surface. The spark

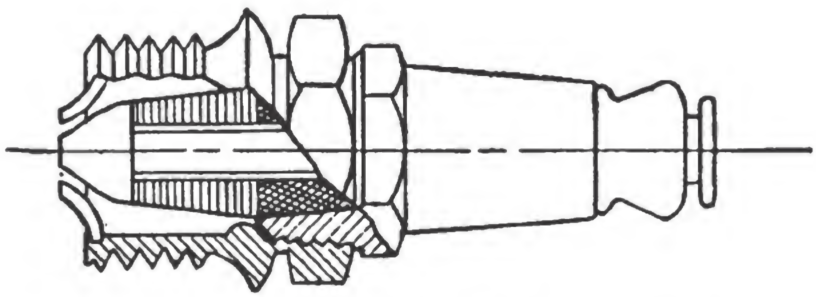


Figure 3–7.—Broken-out section of a spark plug.

plug interior is better shown in figure 3–7 because of the BROKEN-OUT SECTION, which makes it possible for you to "look inside."

ALINED SECTION

Look at the front view of the handwheel in figure 3–8. Notice the cutting plane line, *AA*.

True orthographic projection of a cross section along *AA* will look like the drawing shown in *a*. But you may have to stop and figure out the relation of that cross section to the front view.

By alining both spokes with the cutting plane—that is, so that they touch the cutting plane—the draftsman is able to show a cross section that is much easier to read and understand.

Alining is good draftsmanship. It is the conventional way of simplifying complicated cross sections.

Notice that the spokes are not section lined in *b*. That's the usual way of showing an alined section.

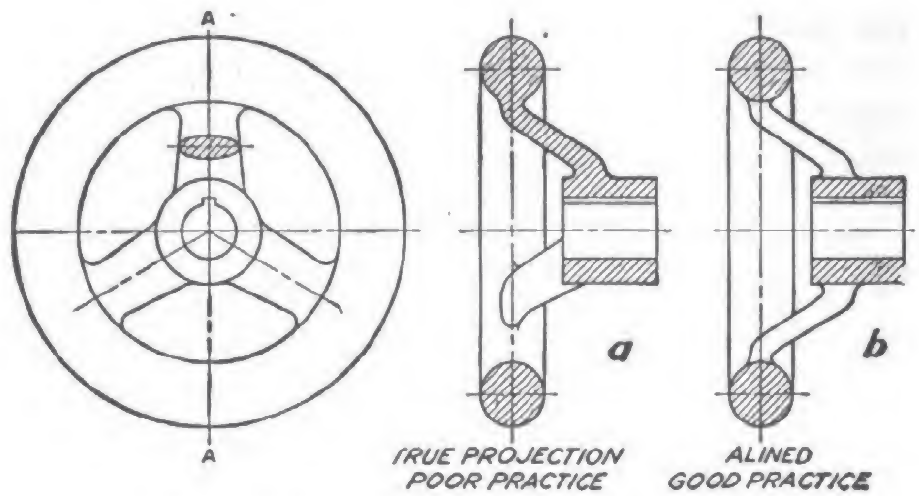


Figure 3–8.—Alined section of handwheel.

CONVENTIONAL BREAKS AND SHAPE SYMBOLS

A long bar or pipe that has a uniform cross section is not always shown in its entire length. By breaking out one or more pieces and moving the ends together, a larger and more readable scale can be used. The true length, of course, is still indicated by the dimensions stated on the blueprint.

The draftsman uses an assortment of lines to indicate breaks in showing different shapes and materials. Figure 3–9 shows some of the conventional breaks employed in drawings to indicate special shapes and symbols.

MATERIAL SYMBOLS

The Munitions Board Standards Agency of the Department of Defense has standardized certain material symbols for section views. You can see a part of this official code in figure 3–10. It will be well worth your while to learn these material symbols.

The symbols shown in figure 3–10 do not indicate specific types; for example, the symbol for metals does not indicate whether a metal is cold-rolled, tungsten, or some other type of steel. The right type will be specified elsewhere on the blueprint. The symbols shown in figure 3–10

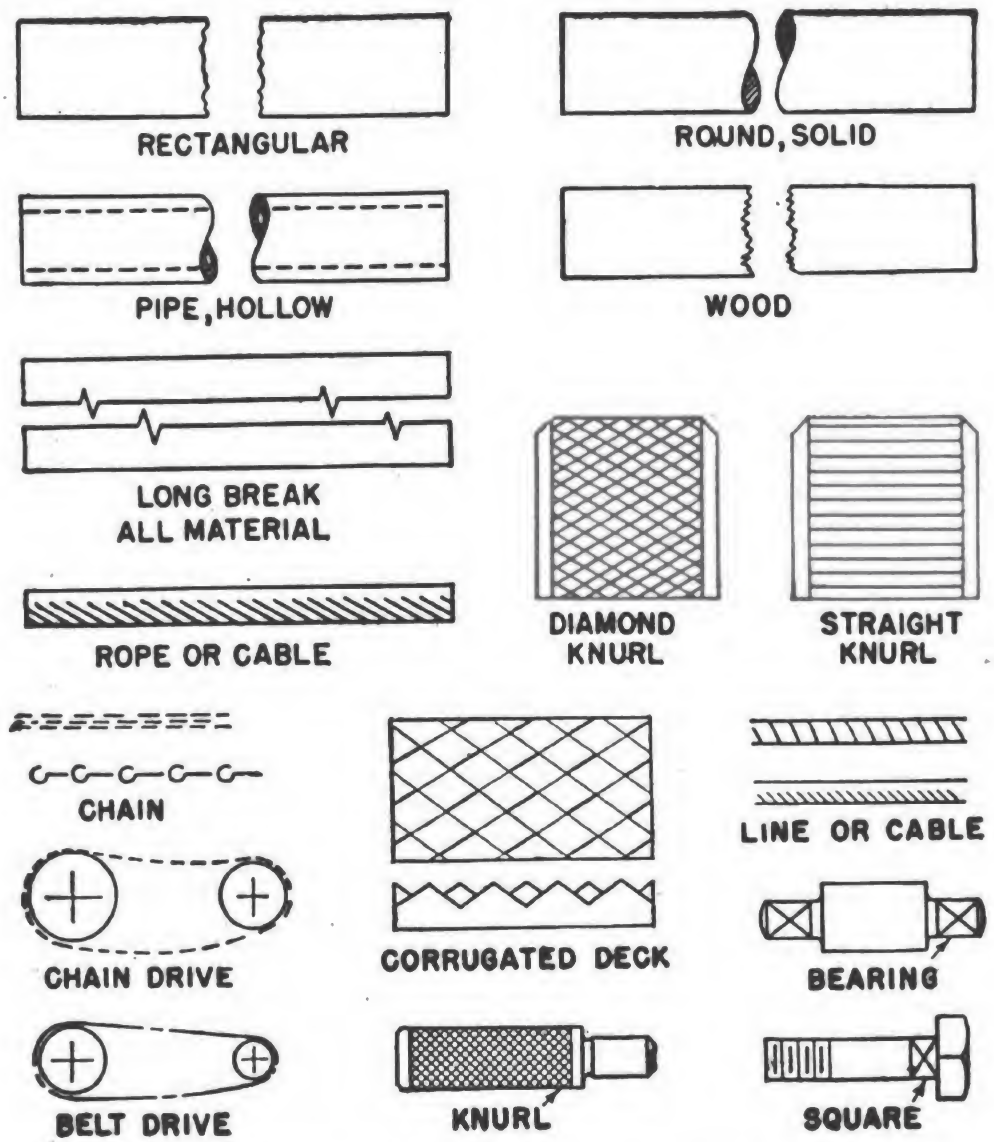


Figure 3-9.—Conventional breaks and special symbols.

are known as SIMPLIFIED SECTIONING CONVENTIONS and their use is preferred wherever practical.

On non-standard prints you may also find other special symbols—and even colors—but such special usages will always be explained in the blueprint legend, that is, in the special information table on the blueprint.

HOW THREADS ARE DRAWN

There are various ways of representing threads. OUTSIDE THREADS are shown in figure 3–11.

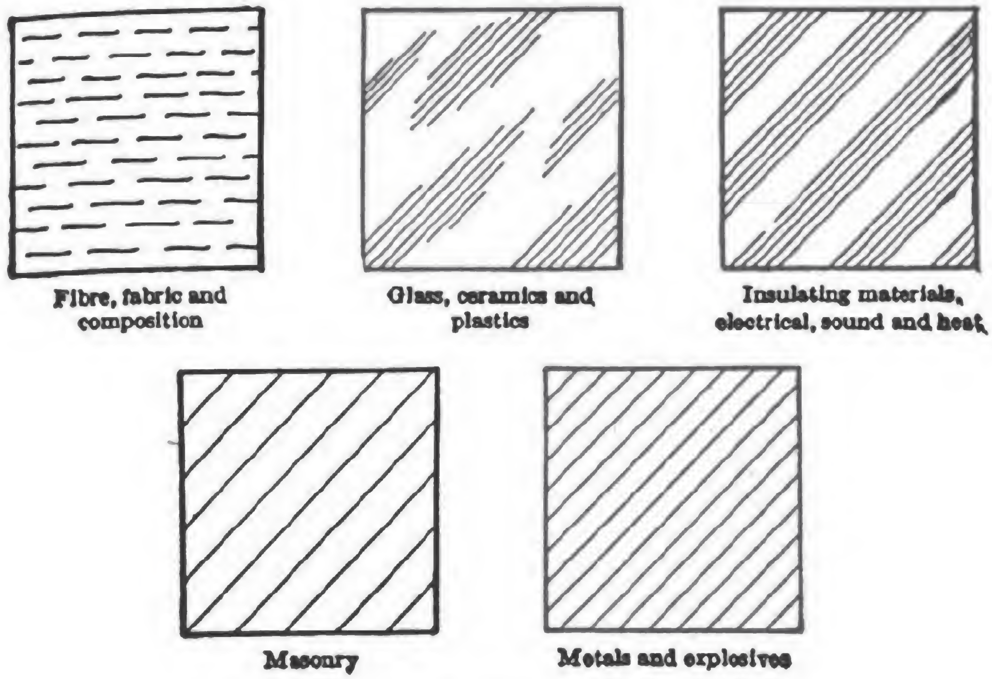


Figure 3-10.—Section lining symbols.

On the left you see a thread profile in section. On the right is a common method of showing threads. To save time the draftsman uses symbols that are not drawn to scale. The length of the threaded part is dimensioned, but other necessary information appears in the NOTE, which in this case is $\frac{1}{4}$-20 NC-2.

The first number of the note, $\frac{1}{4}$, indicates the outside diameter of the thread. The number after the first dash, 20, shows that there are 20 thread points per inch. The letters NC indicate a type of thread, National Coarse. The last number, 2, indicates a No. 2 thread fit, which is a free fit.

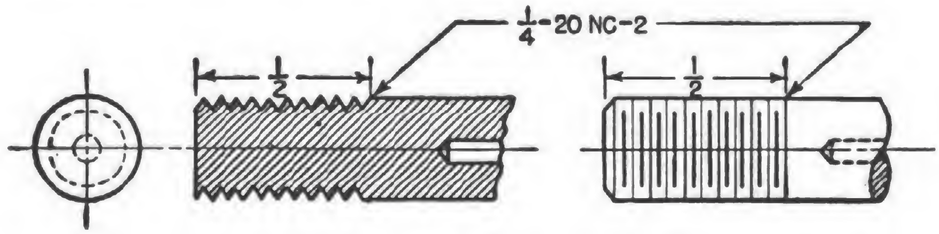


Figure 3-11.—Outside threads.

Specifications necessary for the manufacture of screws include thread diameter, thread series, class of thread fit, and number of threads per inch. There are two pitch series for each thread diameter: a coarse pitch—NC, and a fine pitch—NF. There are more fine threads per inch of screw length than coarse threads. According to thread pitch, the most widely used screw thread is the NATIONAL FORM thread, which includes National Fine, NF; National Coarse, NC; and National Standard, N. Thread fits are classified as:

CLASS 1. Permissible for work in which shake and looseness are not objectionable.

CLASS 2. Most widely used for general work.

CLASS 3. A high-grade thread, possible with precision tools and gages.

CLASS 4. Requires hand selection of threaded parts for best fit.

THREAD FACTORS

Following are definitions of some of the terms commonly used in connection with threads:

PITCH is the distance between corresponding points on two threads.

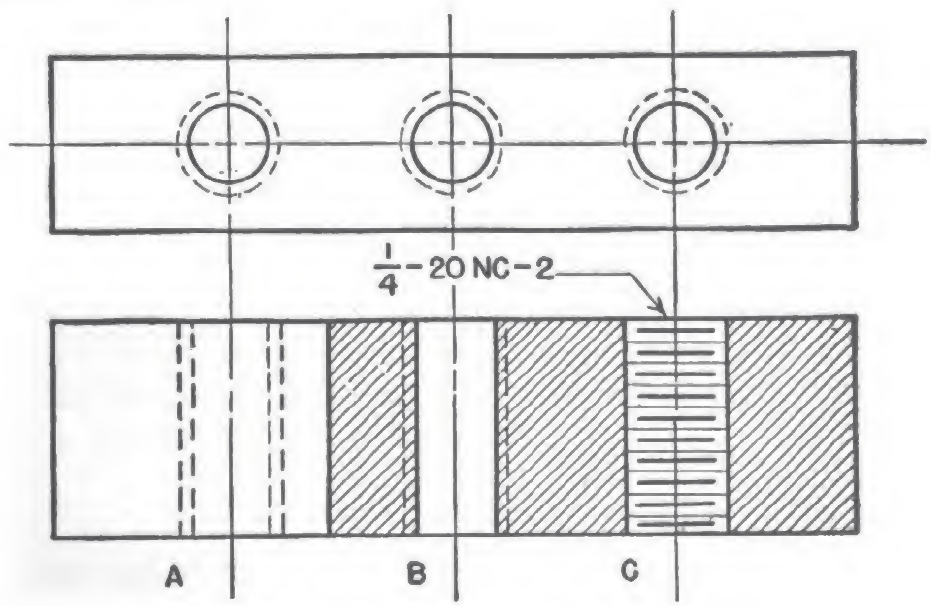


Figure 3-12.—Internal threads.

LEAD is the distance a screw advances in one turn.

MAJOR DIAMETER is the largest diameter of a screw thread.

MINOR DIAMETER is the smallest diameter of a screw thread.

CREST of a thread is its width at the top surface which joins the sides.

PITCH DIAMETER is the diameter of an imaginary cylinder which would cut equally the width and depth of the thread.

ROOT of a thread is its width at the bottom surface which joins the sides.

DEPTH of a thread is its vertical distance, measured from crest to root.

INTERNAL THREADS (fig. 3–12) may be shown by several kinds of symbols. Here again it isn't necessary to draw the threads accurately when an easily drawn symbol will do just as well.

Notice that the threads in figure 3–11 may be screwed

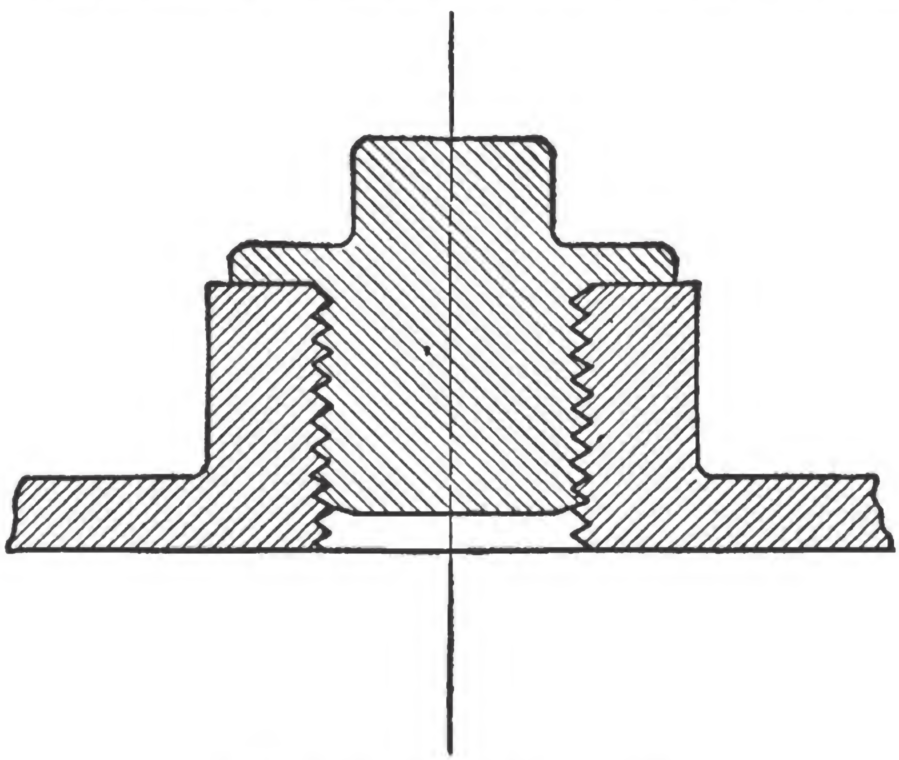


Figure 3–13.—Threaded assembly.

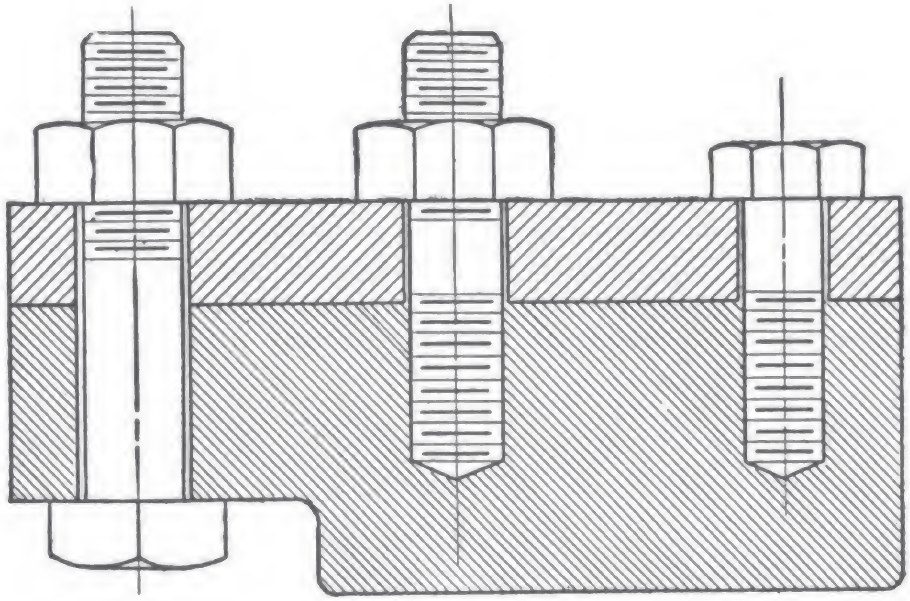


Figure 3–14.—Bolts and studs.

into the threaded holes in figure 3–12. Why? Because the note on each one tells us that the threads are exactly the same.

Threads may be shown IN SECTION, especially in assembly views. Look at figure 3–13. It shows clearly the relationship of the plug and the opening into which it is screwed.

Bolts and studs are indicated on drawings by outlines and symbols, as shown in figure 3–14.

GEARS

Gear teeth generally are not shown on blueprints, except when a few are drawn to indicate the proper dimensions. Figure 3–15 shows how gears may be represented on a mechanical drawing.

GEAR TERMS

Special terms are used to indicate gear measurements. Some of these terms have been added to figure 3–15 for the purpose of the discussion here, but they would not be

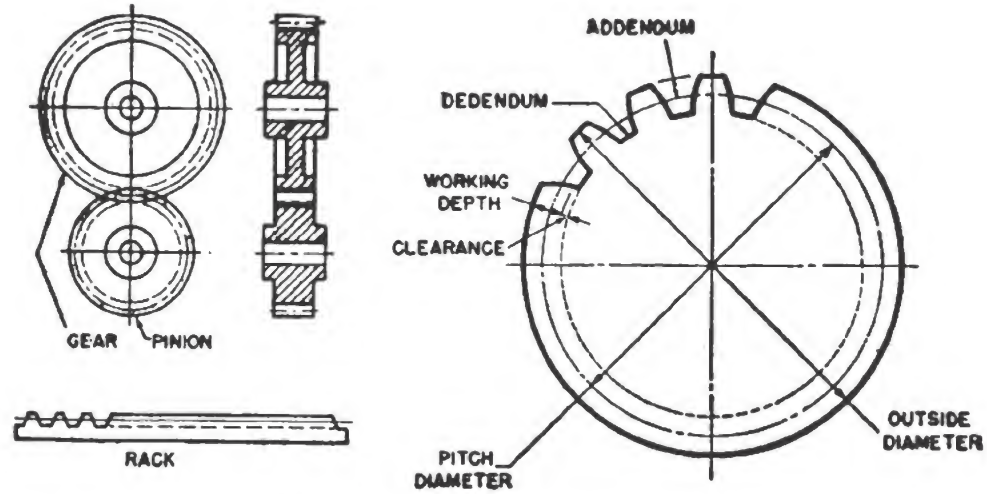


Figure 3-15.—Gear drawings.

so designated on a blueprint. Instead they would appear as notes giving the appropriate dimensions, for example:

Pitch 5
Linear P. .5331
Addendum .1131
Dedendum .0992

Some of the more common terms used with gears are as follows:

FACE WIDTH: distance across the pitch surface of a gear.

PITCH DIAMETER (D): imaginary diameter on which gears would roll as cylinders.

DIAMETRAL PITCH (P): number of teeth per inch of pitch diameter.

PITCH CIRCLE: the circle having the pitch diameter.

CIRCULAR PITCH (P): distance on the pitch circle between corresponding points of two adjacent teeth.

WHOLE DEPTH OF TOOTH (W): distance from the outside diameter to the bottom of the tooth.

WORKING DEPTH (W): greatest depth to which a tooth of one gear extends into the tooth space of another gear.

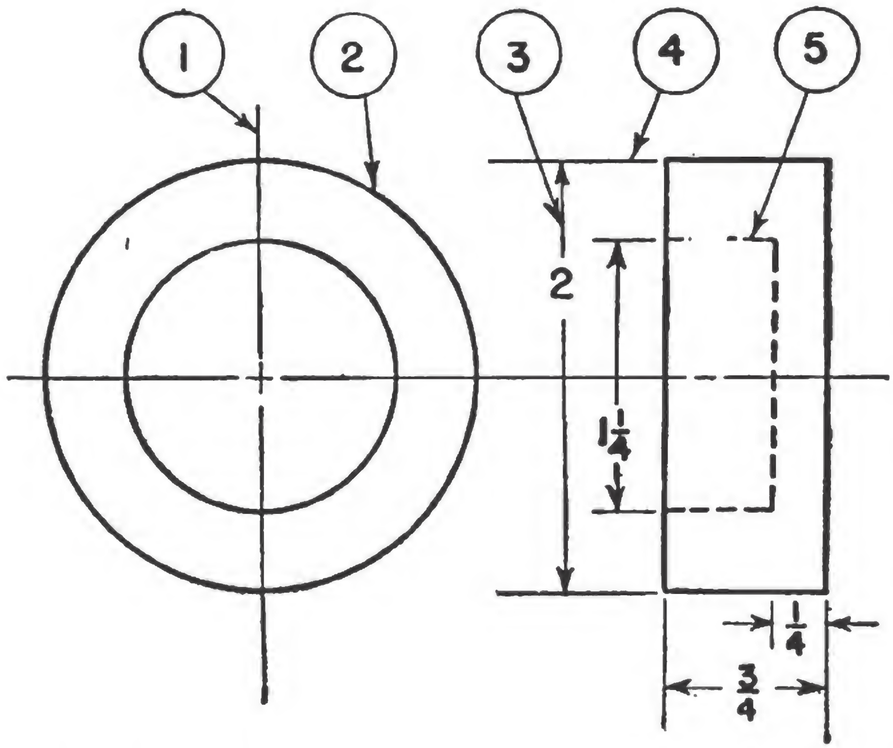
ADDENDUM (S): radial distance from the pitch circle to the top or crest of the teeth.

DEDENDUM (S): radial distance from the pitch circle to the bottom or root of the teeth.

CLEARANCE (F): radial distance from the top of one tooth to the bottom of a tooth mating space.

QUIZ

1. Number your paper from 1 to 5 and write down the names of the five lines in the accompanying illustration.



2. What material symbol is often used to indicate all metals and explosives?
3. What kind of section is shown as a drawing within a drawing?
4. The line running from a note to the indicated position is called what?

CHAPTER 4

DIMENSIONS

DEGREE OF ACCURACY

If you fail to follow the dimensions on a blueprint, you may make a part that will not give the service for which it is designed, and it may break down, endangering the lives of men and defeating the mission they were sent to accomplish. An error of 5/1000 inch can be as destructive as one quarter inch. In fact, a small error may be even more dangerous because it is not so easily detected. The part may pass inspection—it may even perform satisfactorily for a while. But when it breaks down, it may start a destructive chain reaction, damaging other equipment and perhaps even injuring personnel.

932348°—51——4

Absolute accuracy is impossible. Even the 6-inch rule with which you measure is not absolutely accurate. Temperature alone can cause variations in it: cold may cause it to be slightly shorter than 6 inches, and heat may make it slightly longer than 6 inches.

Because engineers realize that absolute accuracy is humanly impossible, they figure how much variation is permissible. This leeway is stated on the drawing as ± a certain amount, as ±1/8, ±1/64, or ±0.005.

LIMITS AND TOLERANCE

The dimension on a blueprint represents the perfect size and is known as the BASIC DIMENSIONS. In figure 4–1 it is 3.0 inches. The limit of error allowed is one-eighth inch. The minimum length is $2\frac{7}{8}$ inches, and the maximum length is $3\frac{1}{8}$ inches.

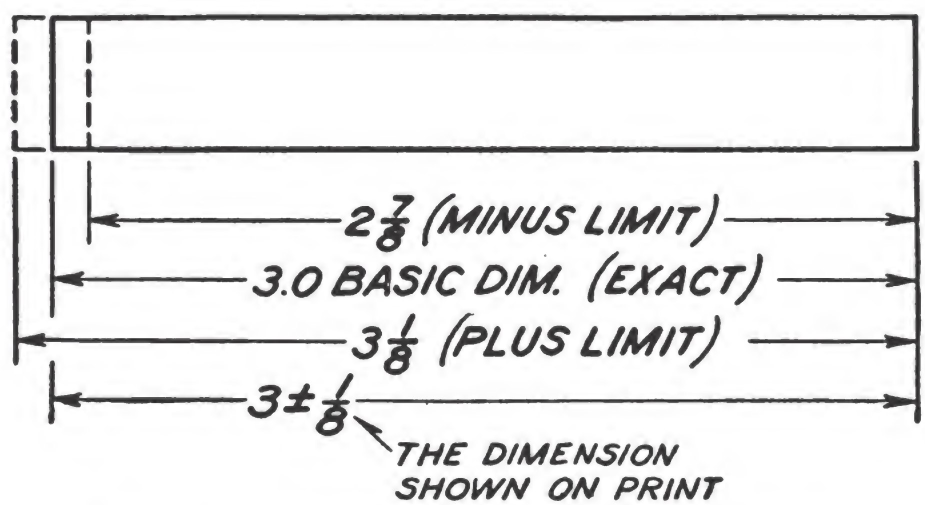


Figure 4–1.—Basic dimension, limits, and tolerances.

Don't expect to have that much leeway on most work. Woodworking usually requires a limit of $\pm\frac{1}{32}$ inch, sheet metal work $\pm\frac{1}{64}$ inch, and machine parts ±0.005 inch or less. Many fine mechanisms have limits of error of ± 0.0001 inch. You can trust your eyes to measure one sixty-fourth of an inch with a rule, but for closer work use a micrometer or special gage.

The difference between the allowable minimum and maximum dimensions (short limit and long limit) is known as the TOLERANCE. In figure 4–1 it is one-quarter inch. Here is another example to show you how the system works:

Basic dimension	$2\frac{1}{2}$
Limits	$\pm\frac{1}{64}$
Long limit	$2\frac{33}{64}$
Short limit	$2\frac{31}{64}$
Tolerance	$\frac{2}{64}$ or $\frac{1}{32}$

These limits, stated in either common fractions or decimal fractions, are found in the title block or legend. Angle limits are stated in terms of degrees, as $\pm\frac{1}{2}°$.

When you're working with limits, try to hit the basic dimension, right on the nose. That will help you to stay inside the allowable limits.

ALLOWANCE

A shaft so large that it must be driven into a bearing won't rotate in that bearing. Some clearance for turning and lubrication is necessary between two moving parts.

A tight fit, known as a DRIVING FIT or HEAVY FORCE FIT, is used to make a permanent assembly. This requires the shaft to have a greater diameter than the hole.

The fits of shafts and holes have been standardized into eight classes, numbered from 1 to 8.

CLASS 1 allows plenty of clearance and is used for fast-moving machine parts of large size.

CLASS 2 is a slightly closer fit and is used for engines, dynamos, and machine tool parts.

CLASS 3 is a snug fit with a very small clearance and is used for extremely accurate, slow-moving parts.

CLASS 4 has no clearance and is the nearest thing to a perfect fit.

CLASSES 5 to 8 allow for the shaft to be increasingly larger than the hole and are used where the shaft does not rotate in the hole.

Remember that allowance is the difference in size of

mating parts, and that it is necessary for their proper operation. Keep in mind that the larger the class number, the tighter the fit.

The allowance for a running fit is known as CLEARANCE and is said to be POSITIVE, because the hole diameter is greater than the shaft diameter. For FORCE FITS, classes 5, 6, 7, and 8, this allowance is NEGATIVE, and the difference allowed is known as INTERFERENCE. The minimum allowable interference is specified by the dimensions given on the blueprint.

BASIC HOLE ALLOWANCE SYSTEM

The BASIC HOLE SYSTEM is a standard method of determining the size of a hole into which a shaft is to be fitted.

The hole can be larger than the basic dimension, but it cannot be smaller. The hole limits are plus only. This is known as a PLUS TOLERANCE.

The shaft has a MINUS TOLERANCE only. It can be smaller than the basic dimension.

Figure 4–2 is a part of a blueprint, showing a shaft and a hole. Can you read it?

The minimum or basic diameter of the hole is 2.500 inches. For a class 1 fit, the allowance is positive, and for a hole this size it is 0.005 inch. This means that the shaft cannot be larger than 2.495 inches or the hole smaller than 2.500 inches. There must be at least 0.005 inch clearance.

The limits for a hole this size are given as ± 0.003. The hole can be as large as 2.503 inches, but no larger. The shaft can be as small as 2.492 inches, but no smaller. The total allowable variation in this particular case is 0.011 inch. The fit must have a clearance of from 0.005 to 0.011 inch.

DIMENSIONS AT WORK

How do you use limits, tolerances, and allowance? There are two ways: for size and for location.

When you work a piece of steel to the proper shape,

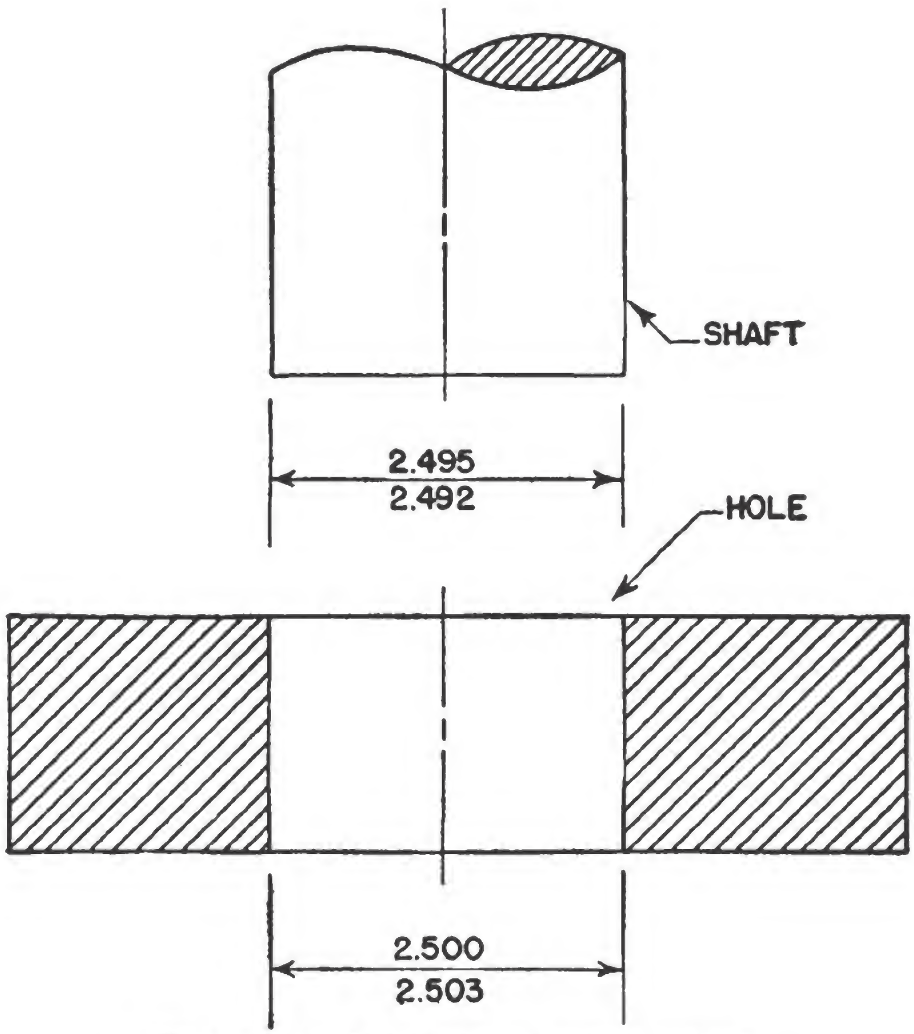


Figure 4–2.—Basic hole allowance system.

you follow the SIZE DIMENSIONS. They tell you the length, width, thickness, and depth. When you locate a hole or a slot, you're following LOCATION DIMENSIONS.

There are many methods that draftsmen use to place dimensions on the drawing. The five examples shown in figure 4–3 cover most of the cases.

CONTINUOUS DIMENSIONS

For small parts that have few location dimensions, CONTINUOUS, or ACCUMULATIVE, DIMENSIONS are useful.

Look at *a* in figure 4–3. Suppose the limits are $\pm 1/32$ inch, which means, of course, that there is a tolerance of one-sixteenth inch. If you cut the stock so that it is one

thirty-second inch under size, it will pass inspection. In laying out the holes, you may make a plus error of one thirty-second inch on each hole. You'll have a total error for all five holes of five thirty-seconds. You've joined each

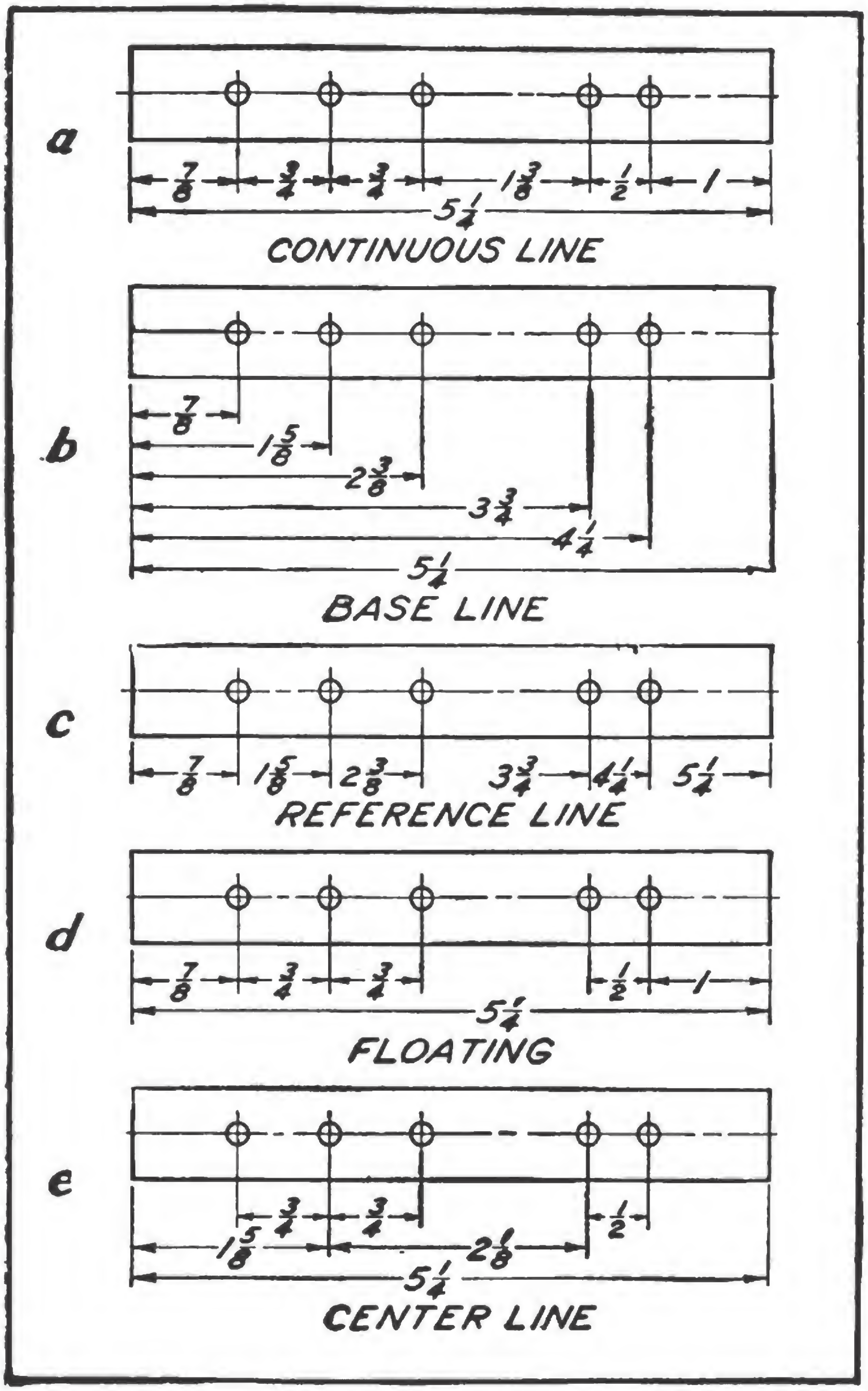


Figure 4-3.—Dimensions at work.

dimension to the preceding one in a continuous line, with the result that all errors have accumulated. There is a possible error as great as three-sixteenths inch.

BASE-LINE DIMENSIONS

You can avoid accumulative errors by using BASE-LINE, or NONACCUMULATIVE, DIMENSIONS. This method is shown in *b* of figure 4–3.

If you use the left end as reference edge, you won't be more than one-sixteenth inch out at most for that last inch, even if you make a $+1/32$-inch error on each hole.

In *c* is a simplified form of base-line dimensioning. You use the reference line exactly as described for *b*. The aircraft industry prefers this form because it takes less space on a blueprint.

FLOATING DIMENSION

To avoid any error in the last dimension, you can use a floating dimension, which will enable you to control the location of the error.

In *d* of figure 4–3, the middle dimension has been omitted. The draftsman expects errors to fall within that space. Measuring the dimensions on either side of the space from left reference edge and a right reference line will put the errors just where you want them.

CENTERLINE DIMENSION

How are you going to get two parts to fit together exactly, hole for hole? Obviously the chief problem is to control the spacing of each set of holes and the distance between the sets. In figure 4–3*e* you can see how the use of the centerline dimension will help you.

There are three holes in the first set. Notice that the draftsman has given $1\frac{5}{8}$ inch as the distance from the reference edge to the centerline of the middle hole. Locate that hole first. Then locate each hole on either side by measuring three-quarters inch from the centerline of the middle hole. That takes care of one set.

From the centerline of the middle hole in the first set, measure off $2\frac{1}{8}$ inches. That's where the first hole in the second set goes. Then, using the centerline of the hole you've just located, measure off one-half inch to the last hole.

The same procedure is used on the other, or mating, part, and the holes then should come together.

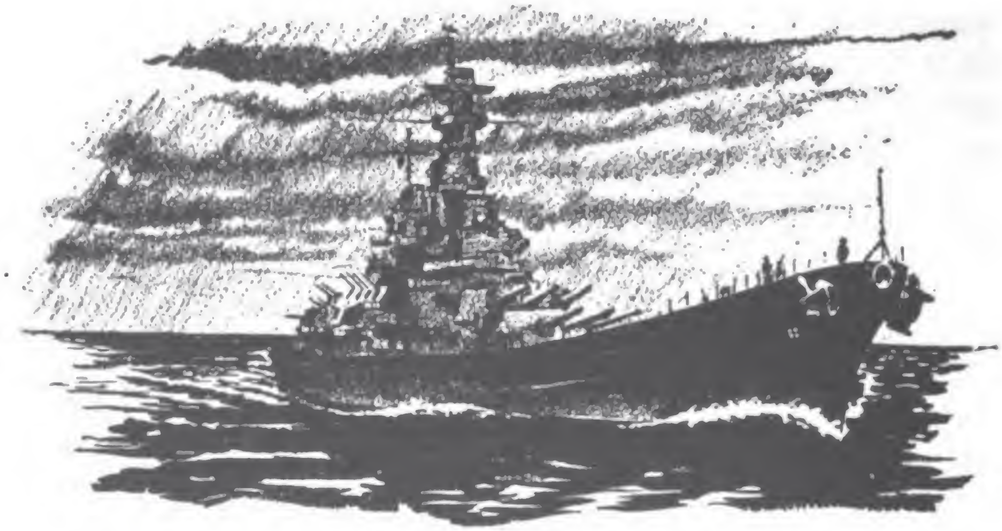
COST OF LIMITS

The engineer or draftsman not only sets the accuracy necessary for the successful operation of the part, but he also keeps its cost in mind. Limits can cost a lot; hence, you should make a part exactly to its specifications, but no more. A small block made with the highest degree of machine workmanship possible (1/500000 inch) would cost about $35.00 on a production basis. That job requires a lot of skill and time.

To make the same block with $\pm 3/1000$ inch—about the thickness of human hair—would cost about $1. Don't give less and don't give more than is called for.

QUIZ

1. a. Why is continuous dimensioning not suitable for parts having many location dimensions?
   b. How does base-line dimensioning avoid the disadvantage of continuous dimensioning?
   c. What is the advantage of measuring inward from the two ends so the one dimension is left "open"?
   d. In what type of dimensioning is this done?
2. You are to use the basic hole system to make a hole 6.500 inches into which a shaft is to fit with minimum clearance of 0.0087 inch. Tolerance is 0.0046 inch.
   a. What is the maximum diameter for each part?
   b. What is the maximum allowable clearance between the two parts?
3. How many points should you measure from to secure an accurate layout?



CHAPTER 5

TITLE BLOCKS, NUMBERS, AND BILLS OF MATERIAL

THE TITLE BLOCK

The headlines on the blueprint are in the title block or box, which is located in the lower right-hand corner of all drawings prepared according to the specifications of the United States Armed Forces. It may appear elsewhere on other blueprints, but the lower right-hand corner is the usual place.

The title block contains the drawing number. It also contains all the information required to identify the part or the assembly that the blueprint represents. In approved military blueprints the title block will include the name and address of the government agency preparing the drawing, the title of the drawing, the scale, drafting record, authentication, and date.

If a space has a diagonal or slant line drawn across it, disregard that space, because the diagonal line indicates that the information usually placed in that space is not required on your drawing.

Revision Block

Each drawing shows a revision block located on the right-hand side of the print. Modern practice is to put this space for the recording of changes in the upper right-hand corner, but it may also be placed above the title if desired. All changes to the drawing are noted in this block and are dated and identified by a number or a letter. If, for some reason, a revision block is not used, a revised drawing may be shown by the addition of a letter to the original number; for example, 103465–26–A.

NUMBERS

Drawing Number

All drawings are identified by a drawing number, which appears in a number block in the lower right-hand corner of the title block. It may be shown in other places also; for example, near the top border line, in the upper right-hand corner, or on the reverse side at both ends so that it will show when a drawing is rolled. Its purpose is to permit quick identification of a blueprint by number. If a blueprint has more than one sheet, and each sheet has the same number, this information is included in the number block indicating the sheet number and the number of sheets in the series.

Reference Numbers and Dash Numbers

Reference numbers that appear in the title block refer you to the numbers of other blueprints. When more than one detail is shown on a drawing, dash numbers are frequently used. Suppose two parts were shown in one detail drawing. Both would have the same drawing number, plus an individual number, as 34105–1 and 34105–2.

In addition to appearing in the title block, the dash numbers may appear on the face of the drawing near the parts they identify. Some commercial prints show the drawing and dash numbers and point with a leader to the part; others use a circle, three-eighths inch in diameter,

around the dash number, and carry a leader to the part.

Dash numbers are also frequently used to identify right-hand and left-hand parts.

Many aircraft parts on the left-hand side of an airplane are exactly like the corresponding parts on the right-hand side—in reverse. The left-hand part is always shown in the drawing. The right-hand part is called for in the title block.

Above the title block you'll see a notation such as "159674 LH shown; 159674–1 RH opposite." Both parts carry the same number. But the part called for is distinguished by a dash number. LH means left hand, and RH means right hand. Some companies use odd numbers for left-hand parts and even numbers for right-hand parts.

Zone Numbers

Zone numbers on blueprints are similar to the numbers and letters printed on the borders of a map to help you locate a particular point. To find a point, you mentally draw horizontal and vertical lines from these letters and numerals, and the point where these lines intersect is the area sought.

You'll use practically the same system to help you locate parts, sections, and views on large blueprints (usually assembly drawings). Parts numbered in the title block can be located on the drawing by looking up the numbers in squares along the lower border. Zone numbers read from right to left.

Station Numbers

On large assemblies—airplanes, for example—a numbering system is used to help locate STATIONS on the assembly, such as fuselage frames. When you see "Fuselage Frames—Sta. 187," you know that the frame is 187 inches aft the nose. The measurement is usually taken from the nose or zero station of the airplane, but sometimes it is taken from the firewall.

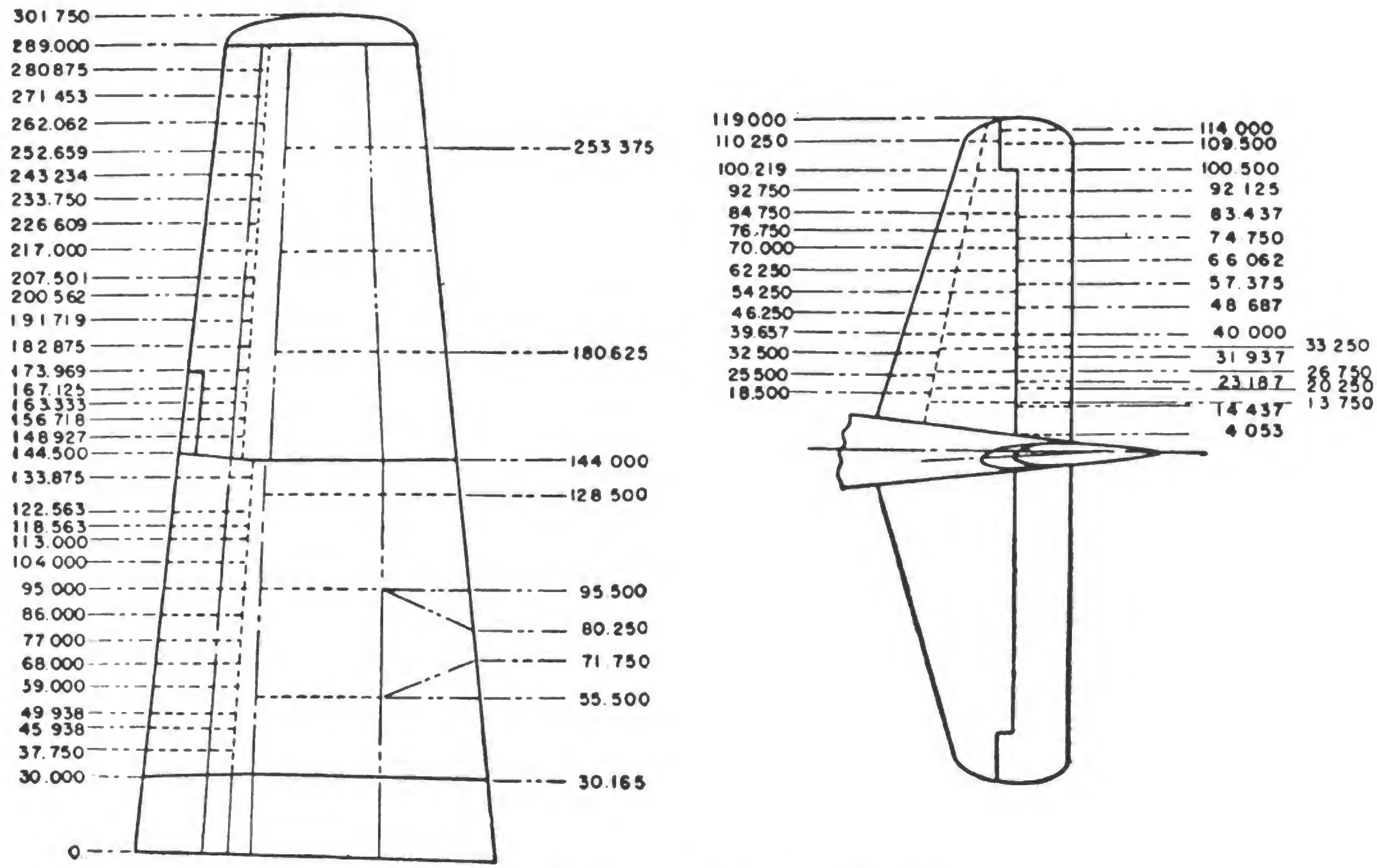


Figure 5-1.—Stations and frames. (Part 1.)

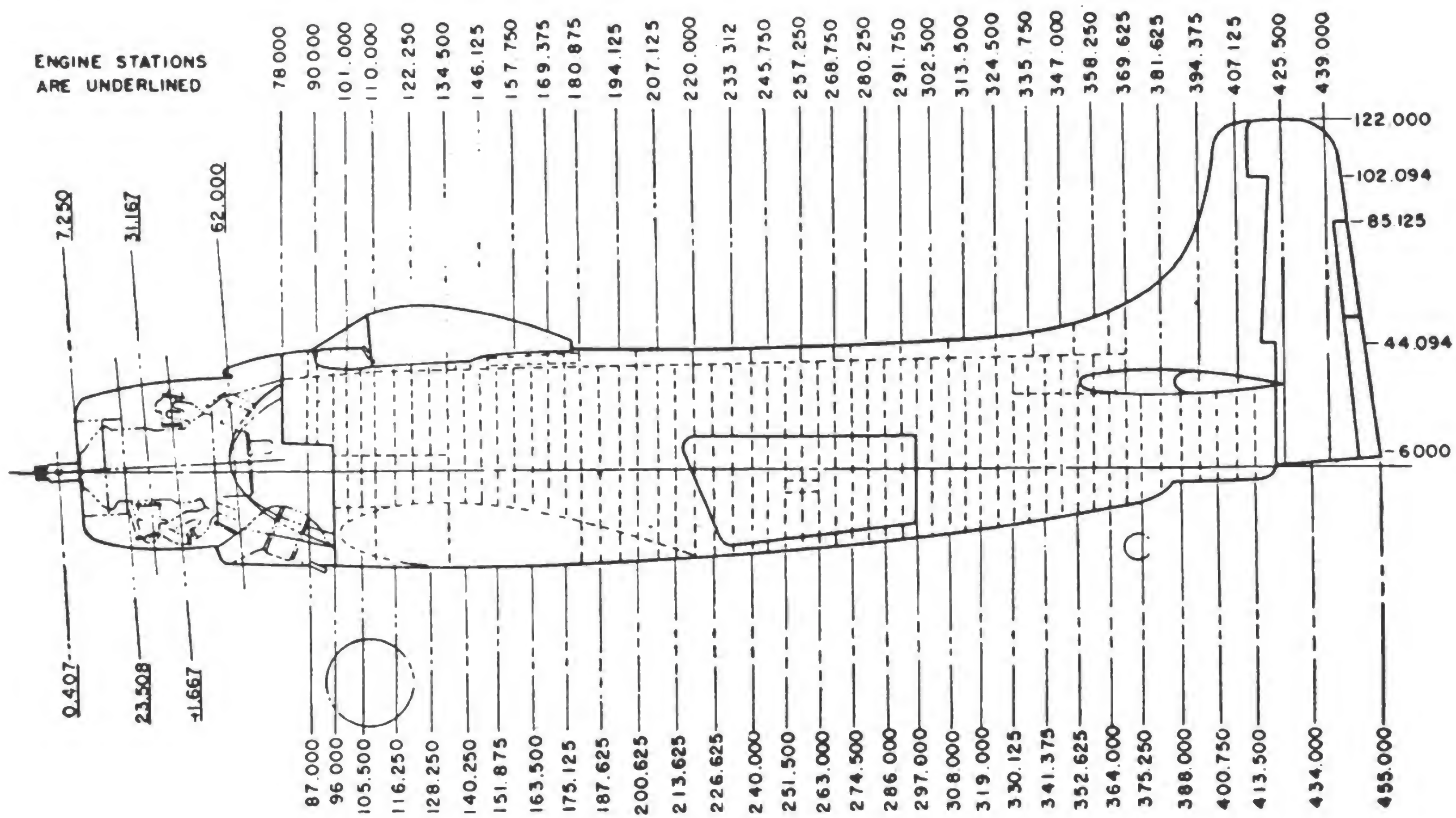


Figure 5-1.—Stations and frames. (Part 2.)

The same station system is used for wing and stabilizer frames. The measurement is taken from the centerline, or zero station, of the airplane. Station numbers for a typical aircraft are shown in figure 5–1.

SCALE

The scale of the drawing is indicated in one space of the title block. It indicates the size of the drawing as compared with the actual size of the part. The scale is usually stated as 1″ = 2″, 1″ = 12″ etc. It may be indicated as full size, one-half size, one-fourth size, etc.

If the draftsman uses a scale of 1″ = 2″, the object is shown half as large as its actual size. For a scale of 3″ = 1″ the object or part is drawn three times its actual size.

Very small parts are enlarged, and large objects are reduced in size, to show the views clearly. The scale is selected to fit the object being drawn and the space available on the sheet.

Remember: NEVER MEASURE A DRAWING. USE THE DIMENSIONS.

Graphical scales are often placed on maps and drawings. These scales indicate the number of feet or miles represented by an inch. Oftentimes a fraction is used, as 1/500, meaning that one unit on the map is equal to 500 like units on the ground. A LARGE-SCALE MAP has a scale of 1 in. = 10 ft.; a map with a scale of 1 in. = 1,000 ft., or 1/5000, is termed a SMALL-SCALE MAP.

An architect's scale is divided into fractional parts of an inch, as eighths, sixteenths, thirty-seconds, etc.

An engineer's scale is used for drawing plans and maps. The scale is usually of triangular cross-section and thus provides six different scales on one rule. Some engineers' scales are flat, with both edges beveled, and provide four scales. Surveyors' plans are plotted to a scale of feet to inches. The engineer's scale is divided into parts to an inch, as, for example, 10 parts to an inch. If the scale is

1 in. = 20 ft., the scale in which the inch is divided into 20 parts is used.

MATERIAL SPECIFICATIONS

Always use the material specified. Never make a substitution unless you have the proper authorization. The material indicated was selected by an engineer because it met the requirements of the job. It's the best material for that particular job. Only an engineer or a man having the authority of an engineer for a particular piece of work can authorize substitutions of material when the kind specified is not available.

Later in this chapter we will say something about the list or bill of materials which further specifies what materials to use.

HEAT TREATMENT

Practically all metals require some form of heat treatment in a manufacturing process. The title block on a blueprint, drawing, or specification lists the type of heat treatment required. Frequently it is necessary to remove the temper from a piece of metal, in order that it may be machined to specifications, after which it must be rehardened. Reference should be made to the heat treatment specifications in the title block, to determine the type required and the point during processing at which heat treatment is to occur.

FINISH MARKS

Finish marks are used to indicate surfaces that must be finished by machining. Finishes are applied to prevent wear, rust, corrosion, and to provide fits with closely mated parts. In manufacturing, during the finishing process, the required limits and tolerances must be observed. MACHINED FINISHES should not be confused with finishes of paint, enamel, grease, chromium plating, and similar coatings.

On drawings not prepared according to current govern-

mental specifications, the draftsman may indicate the edges to be finished by placing a small letter *f* on the line representing the finished edge, or he may use the capital letter *V*. When so used, either one is called the FINISH MARK.

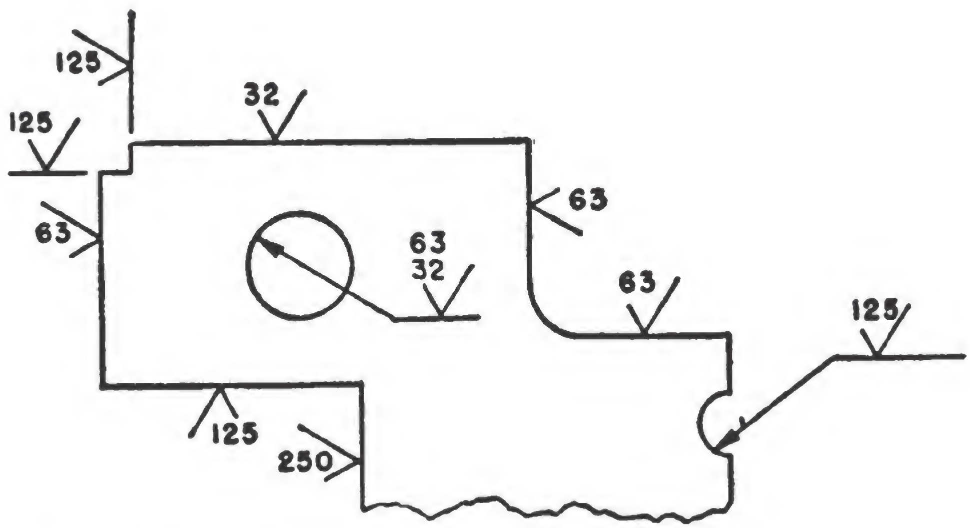


Figure 5–2.—Methods of placing the surface roughness symbol, indicating finish of certain surfaces.

Drawings prepared according to government specifications require the use of a surface roughness symbol, as shown in figure 5–2. The number inside the surface roughness symbol is the surface roughness number. Waviness and lay numbers may also be used. Full requirements for the use of these symbols may be found in *Military Standard Surface Roughness, Waviness, and Lay* (MIL–STD–10, 2 August 1949).

BILL OF MATERIAL

A special box on the drawing may contain a list of the pieces of stock necessary to make a part or an assembly of several parts. It's called a bill of material and tells the kind of stock, the size, and the specifications.

The bill of material for an assembly drawing often has a list of standard parts. Many commonly used items, such

as machine bolts, screws, turnbuckles, rivets, pipe fittings, and valves, have been standardized by the Army, Navy, and Air Force. Each item has a number with AN in front of it. A wing nut, for example, has an Army-Navy specification of AN 350; a flathead sheet-metal screw is listed as AN 531.

USAGE BLOCK

A usage block may be used to identify by their drawing numbers the larger units of which the detail part or subassembly shown on the drawing forms a component. This block is usually near the title block, or it may form a part of the list of material block. Figure 5–4 shows this block in two parts. The solid lines form the basic block and the dash lines indicate quantity columns which may be added when required.

NEXT ASS'Y.	USED ON	NEXT ASS'Y	FINAL ASS'Y
APPLICATION		QUANTITY REQ.	

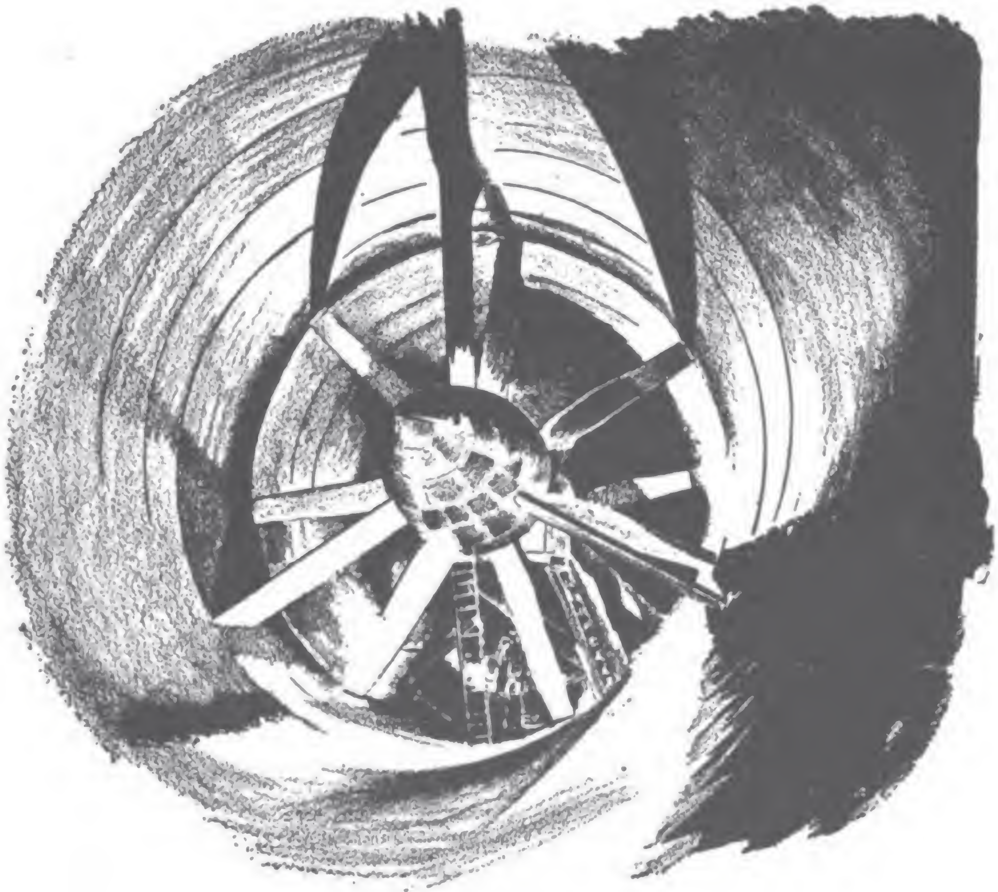
Figure 5–4.—Usage block.

QUIZ

1. Why is a number stamped, cast, or stenciled on each part of a machine or engine?
2. a. What would these symbols in a blueprint's title block tell you?

   Ring—Fuselage—Sta. 209½.

   b. Explain how zone numbers could help you if you were trying to find a view of this fuselage ring on a large assembly blueprint.
3. Where on the blueprint can you always find over-all dimensions of the part you are to make?
4. How and where is a change from original design usually designated on blueprints?



CHAPTER 6

LAYOUT TOOLS

LAYOUT WORK

Laying out is the method of placing lines on the stock to correspond to the lines and dimensions of the blueprint. These layouts are full size and must be measured and marked accurately on the stock. Limits and allowances must be observed.

The layout includes object outlines and centerlines. Hidden lines are omitted. Dimensions and notes are NOT written on the layout.

To locate, measure, and mark the layout accurately, you need to know two things. The first is how to follow a good layout procedure, step by step; the second is

how to use the best precision layout tools and keep them in excellent condition at all times.

Follow the blueprint, learn the procedure, use your layout tools properly, and you'll have no trouble with layout work. In this chapter you learn about the tools; procedure is discussed in a later chapter.

PENCILS

Use a pencil for layouts on wood and on some sheet metals, such as aluminum and tin plate. For woodwork you may use a carpenter's flat lead pencil. If one isn't available, you can sharpen a common lead pencil to a chisel point, as shown in figure 6-1. The chisel point will stay sharp longer than the round point and won't break so easily.

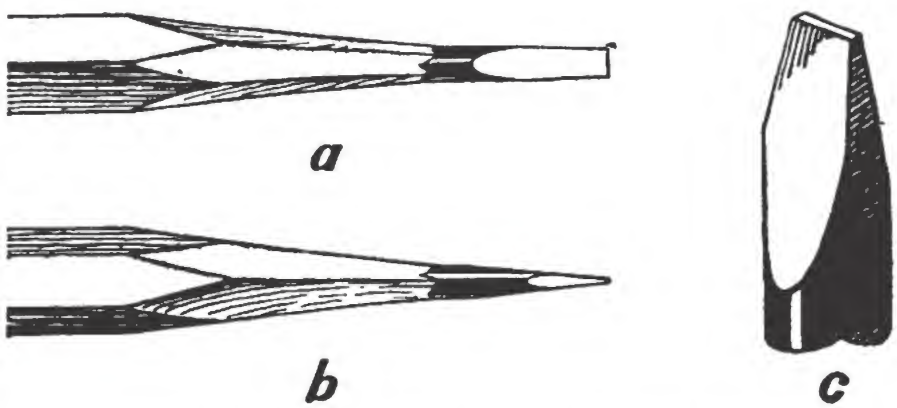


Figure 6-1.—The correct way to sharpen pencils.

You can use a round-pointed pencil if it has a sharp point that makes a fine, clean-cut mark. The layout lines must be accurate.

SCRIBER

A well-sharpened scriber is used to make clean, narrow, accurate layout lines on metal. The scriber mark is easy to see and does not rub off or smear.

The plain machinist's scriber is a slender piece of tool steel, tapered to a sharp point at each end. One end may

be bent at a right angle for marking lines in tight places. It's a good shop tool, but don't carry it around in your pocket—it's too dangerous.

If you work away from the shop, carry a pocket scriber like the one shown in figure 6–2*a*. The marking point of the pocket scriber is removable. You can release the point and place it inside the handle. All scribers have a non-skid grip so that they won't slip when you're marking the layout lines. The pocket scriber has a knurled handle.

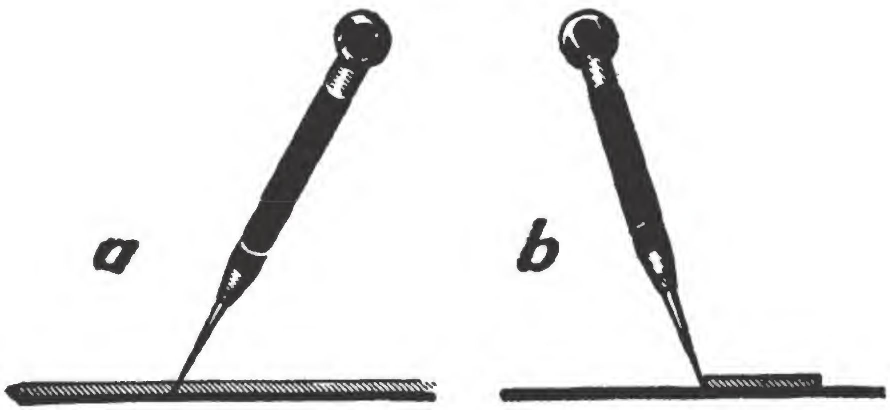


Figure 6–2.—Using the pocket scriber.

Before you use a scriber, check the point. Be sure it's round and sharp. To keep the point in good condition, touch it up on an oilstone. Keep revolving it in your hand as you sharpen it. This action will keep the point round.

Here are a few pointers on using the scriber. First of all, hold it firmly, just as you hold a pencil. In figure 6–2*a* the scriber is shown at an angle with the stock. Hold it in that position when marking along a straightedge. Notice at *b* that the scriber is tilted away from the edge, so that the point will mark right along the lower edge. Apply even pressure or you'll get a broken, jumpy line.

Make a firm, strong line the FIRST time. Don't retrace—you may slip off the track and get a blurred line or a double line.

No matter how careful you are, you'll be a few thousandths off with your scribed lines. But if you follow the rules, you can stay well within the prescribed limits of accuracy.

MACHINIST'S STEEL RULE

The stock you mark with scriber or pencil is measured with a rule. The most accurate type is the machinist's steel rule. It's a precision instrument that is made of flat spring steel and graduated in inches and parts of inches. The best ones are graduated in eighths and sixteenths on one surface and thirty-seconds and sixty-fourths on the opposite face. Standard lengths are 6 inches and 12 inches, but you may find longer rules in your shop.

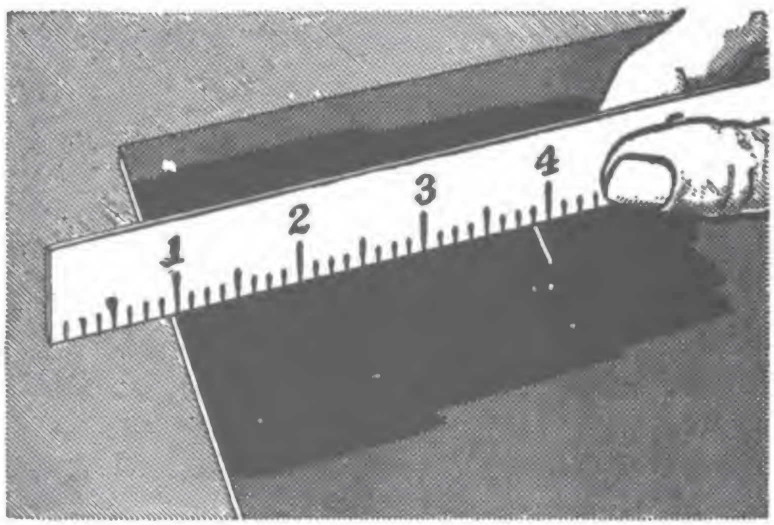


Figure 6-3.—Using the machinist's steel rule.

The graduation marks are about 0.005 inch wide. The perfect measurements are to the centers of those marks. You can't make accurate measurements if the rule is scratched and dented or if its marks are worn away. When you aren't using it, keep a thin film of oil over it, and stow it in a leather case. Don't just toss it in the toolbox with other tools.

There are some tricks of the trade that help you to

secure accurate measurements for your layout. Notice that the graduation marks touch the surface of the stock. By holding the rule on edge, you can pick the marks right off the rule onto the stock with your sharp scriber.

Notice that the measurement is NOT made from the END of the rule. The ends may wear off, so always measure from the one-inch mark.

Be sure you can see the marks on the rule and the layout. Try to work where you will have the best available light.

Clamp the stock in the vise or lay it on the bench. Hold the rule in one hand and the scriber in the other.

When you mark off a dimension or scribe a line, check it with your rule—immediately. Be sure that the mark is right on the dot before you make another measurement.

You will also use the rule to check the part as you make it. When the part is completed, it will be checked in all possible ways with a rule. This check is to make sure that the part is within the limits specified on the blueprints.

STRAIGHTEDGE

You may use your rule as a guide for scribing straight layout lines. You can also use a straightedge, which is like a rule except that it's longer and has no graduation marks. You can't measure with a straightedge.

If you keep your straightedges in good condition, you'll always have a reliable guide for scribing long, straight lines and for checking flat surfaces. Oil it and put it away carefully when it's not in use. Keep it straight.

DIVIDERS

When you were in school, you used a pencil compass to draw circles on paper. You may remember that the compass often slipped, so that the line didn't come back to the starting point. This won't happen if you use dividers (figure 6–4). They're precision tools for laying

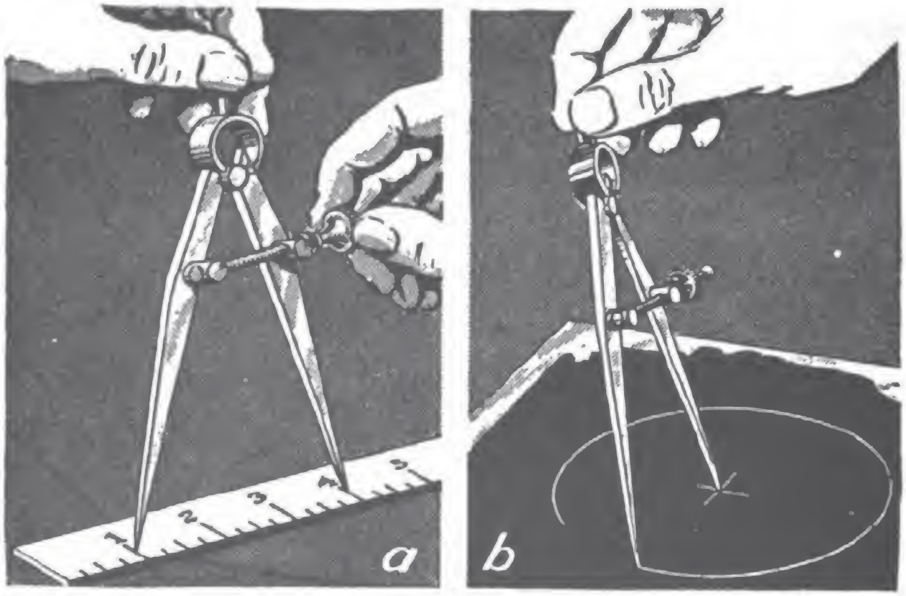


Figure 6–4.—Setting dividers; swinging an arc.

out arcs and circles and for checking and marking distances.

The toolmakers' dividers have a screw adjustment (shown in the illustration) and can be set accurately. Notice the setting method in *a*. The layout man is setting them from the one-inch line so that the setting will be accurate.

Before the layout man scribes the circle, as in *b*, he will check the setting by marking a circle on a piece of scrap stock and checking the diameter with his rule.

Be sure the points of your dividers are sharp, and when you set them, hold the legs together with one hand while you make the adjustment with the other hand. This allows the nut to turn easily and prevents unnecessary wear on the screw thread. This method provides an approximate setting, and the final setting is made as shown in figure 6–4*a*.

When the layout man scribes an arc on metal, he calls it SWINGING AN ARC. Notice how you hold the dividers for swinging the arc—by the handle instead of the legs. If you use a smooth, steady swing and lean the marking point in the direction you're swinging, you'll get a well-

defined mark the first time around, and you won't have to retrace it. Traceovers usually result in a loss of accuracy and should be avoided.

The size of a pair of dividers is the length of one leg. You may have some as small as 3 inches or as large as 12 inches.

TRAMMEL POINTS

For jobs requiring large arcs and circles you'll use trammel points. Figure 6–5 shows how they're used. The

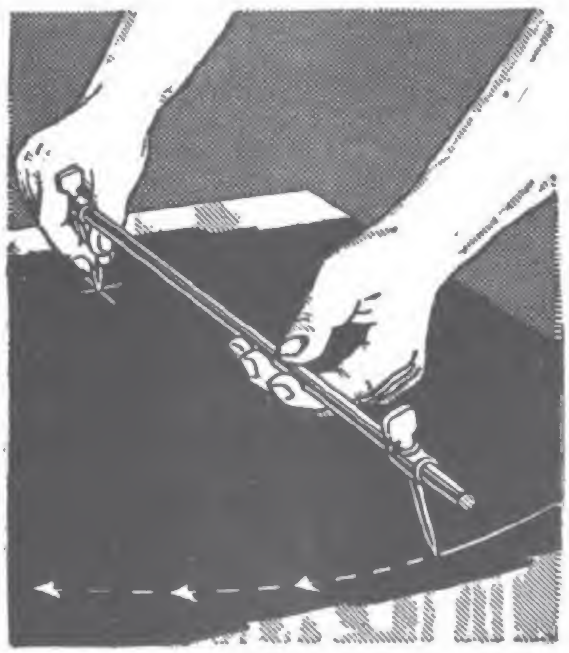


Figure 6–5.—Trammel points.

points, or legs, are attached to a bar by means of lock screws. When you use the trammel, make sure there's no sag in the bar, and keep the screws tight, so that your radius won't walk away from its intended path. Incline the trammel in the direction of the arc and keep that angle constant while swinging the entire arc or circle.

If you need a trammel and none is available, you can devise a good substitute with a thin wood slat and a couple of sharp nails.

SQUARES

Squares are used to draw angles. Most of the time you'll use squares to make layout lines at right angles (90°) to squared edges; but occasionally the lines will be at angles other than 90°.

For large parts, especially those made of sheet metal and wood, you'll use the STEEL SQUARE (*A* in fig. 6–6). The common TRY-SQUARE (*B*, fig. 6–6) is used where long lines are not required.

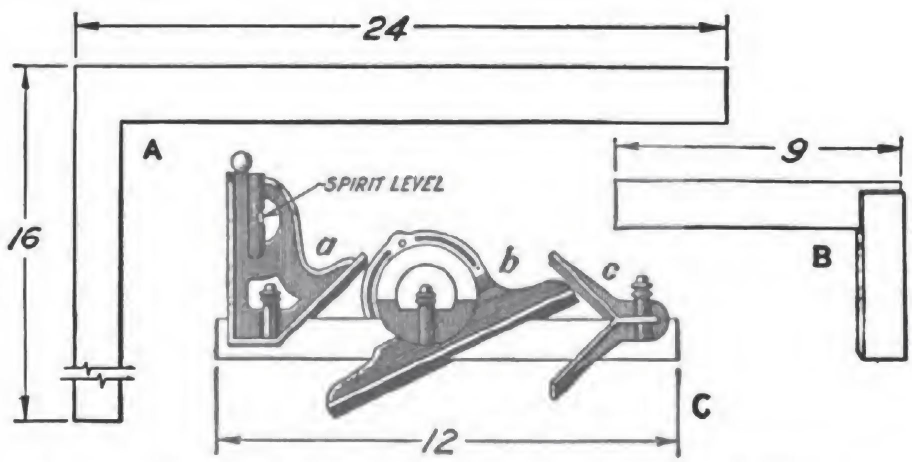


Figure 6–6.—Steel square, try-square, and combination set.

When you need to make extremely accurate layouts you'll use your COMBINATION SQUARE SET (*C*, fig. 6–6). This is an extremely practical tool for layout work and for checking angles and surfaces.

The combination set has one 10-inch or 12-inch blade, to which three types of head may be fitted.

Head *a* (fig. 6–6), known as the STOCK, gives you a perfect 90° try-square or a tool for laying out and marking 45° angles. This head contains a spirit level. It's handy for leveling up your work, but don't try to use it on a pitching and rolling ship. Figure 6–7 shows how the square stock and blade may be used.

The center illustration in figure 6–7 shows the use of the CENTER HEAD. You'll use the center head to locate the center of a round bar or shaft.

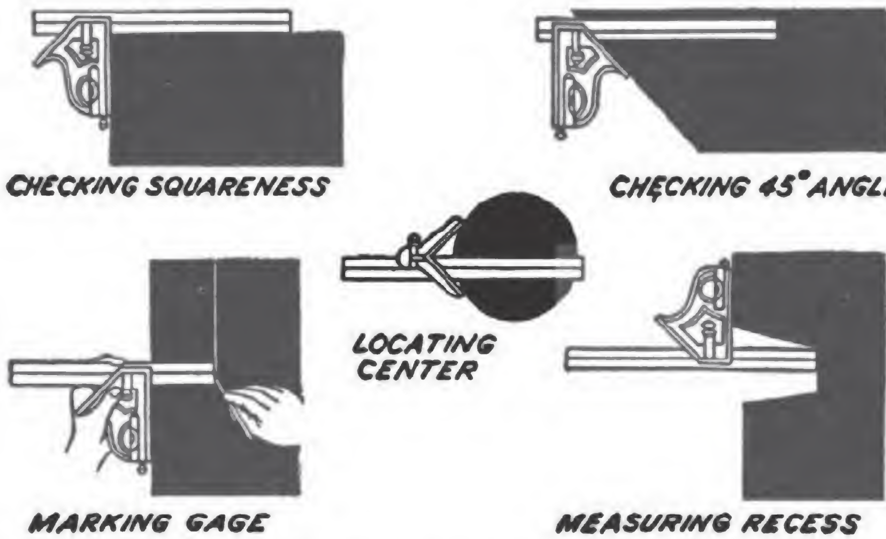


Figure 6–7.—Some uses of the combination square set.

For laying out any angle, other than 90° or 45°, the PROTRACTOR is used. Set it to the desired angle on the semicircular scale that's graduated in degrees. Two locking screws prevent the protractor from slipping out of adjustment. A simplified type of protractor is shown in figure 6–8.

When, in using any square, you hold the stock or head

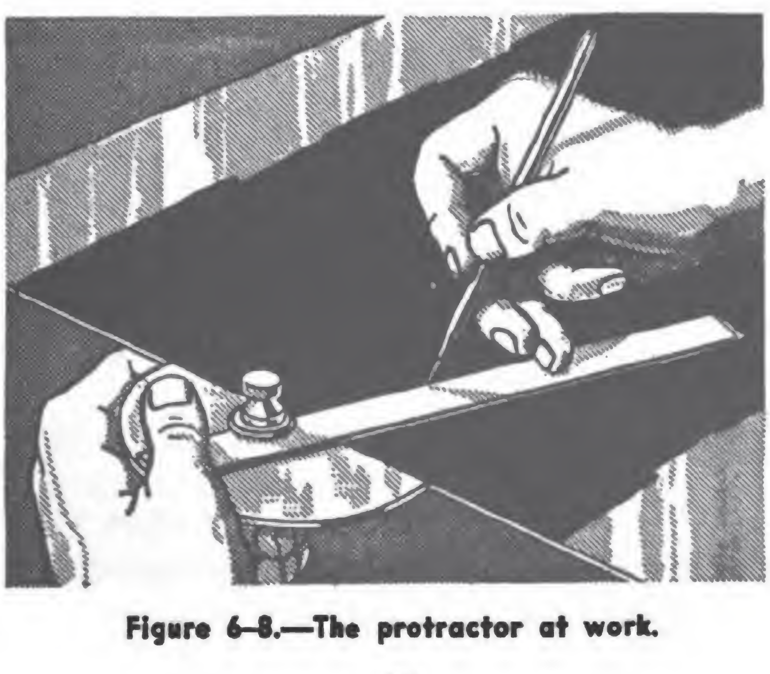


Figure 6–8.—The protractor at work.

against a squared edge or surface, be sure to hold it TIGHTLY against that surface. Keep the blade of the square in contact with the surface you're marking, to prevent the scriber from slipping under the edge.

Handle all squares with care. If they are dented, cracked, or sprung, they are worse than useless. Don't drop them on the deck or throw them in the tool box with other tools. Handle your squares as carefully as you handle your wristwatch.

PUNCHES

When you swing an arc with the dividers, you swing it from a point located at the intersection of two lines.

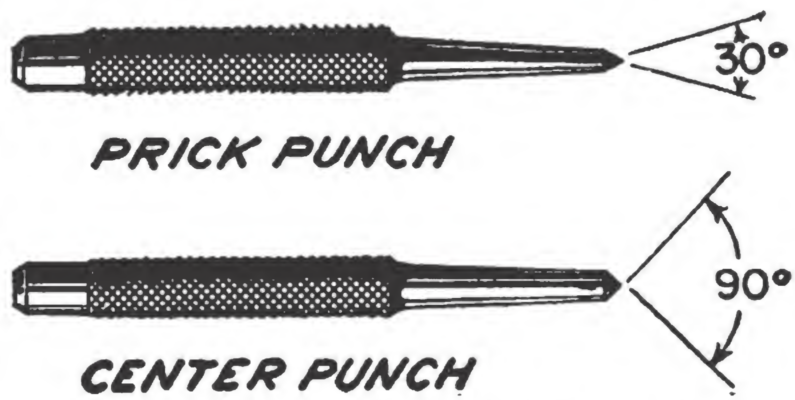


Figure 6–9.—Prick punch and center punch.

If you placed one point of the dividers on the intersection, it would slide away unless you had prick punched the intersection, The small indentation made by the prick punch provides a seat in which to pivot the divider point.

The prick punch, figure 6–9, is 4 or 5 inches long, and has a knurled grip and a round, sharp point. To make the mark, tap the prick punch lightly with a light (4-oz.) ball peen hammer.

To get the mark exactly in the center of the intersection, move the point of the prick punch along one of the scribed lines until you feel it hit the other line. Then straighten the punch and tap it with the hammer.

Now check the location with your eye and with the rule.

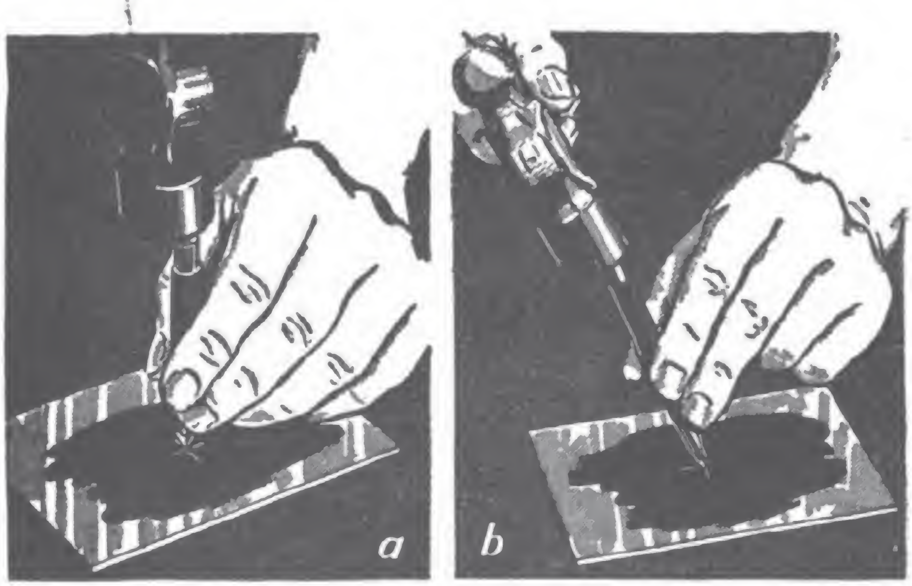


Figure 6–10.—Using the prick punch.

Hold the rule on edge and measure from the 1-inch mark. Is the punch mark where it belongs? If it's off-center, try to drift it over, as shown in figure 6–10*b*. Place the point in the mark and tap the punch in the desired direction. Tap gently, to make a small hole.

Center Punch

The prick punch marks that locate the centers of holes may be enlarged with a center punch just before the hole is drilled. It has a wide angle (about 90°) and is used to guide the drill when the hole is made. Use an

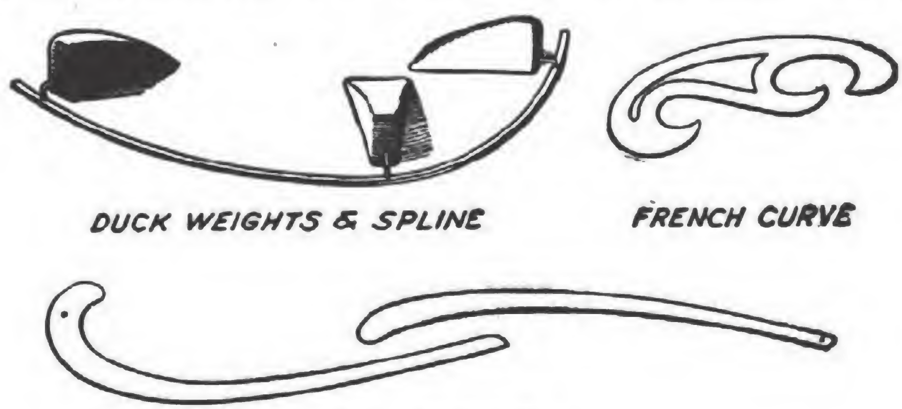


Figure 6–11.—Duck weights and spline; ship curves and french curve.

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8- or 10-ounce hammer, and hit the center punch one solid blow. Be sure to hold the punch exactly perpendicular to the surface.

When you grind either type of punch, rotate the point, to keep it round. Be sure to maintain the proper angle for the punch you're grinding. Don't let it get hot enough to turn blue or black because that much heat will soften the point. To prevent overheating, dip the point in water at frequent intervals.

SPECIAL LAYOUT TOOLS

Some tools used as guides for marking curved line layouts are shown in figure 6–11.

Small irregular curves are easily handled with a FRENCH CURVE. They are obtainable in several shapes and styles.

For larger and longer curves, use the SHIP CURVE or the SPLINE and DUCK WEIGHTS. In the lofting room, the spline and duck weight system is necessary to lay out ship and boat curves full size.

Irregular curves are drawn through fixed points on the layout. Try to fit the outline of the tool to at least three points at one time. Be sure the curve is smooth and unbroken.

Ship curves and french curves ordinarily are made of transparent plastic. Without proper care and stowage. nicks and scratches will develop rapidly.

CHECK THE LAYOUT

Do your best to get an accurate layout the first time. You won't have much layout trouble if you work carefully and check everything as you go along. Speed will develop with PRACTICE and EXPERIENCE.

After you have finished a layout, don't start to work right away. Stop a minute and take a breath. Then check the layout as though you are seeing it for the first time. It is better to catch an error on the layout than on the part after you have started to work.

QUIZ

1. a. What are the primary layout tools used for the following purposes?

   1. Drawing narrow lines on metal.

   2. Laying out long straight lines.

   3. Precision scale measurement.

   4. Transferring distances; comparing dimensions; scribing arcs.

   5. Establishing points for placing divider legs.

   6. Establishing right angles and parallel lines from reference edge; serving as guide or reference edge for other instruments.

   7. Constructing angles from reference edge.

   8. Scribing small irregular curves.

   b. Mention at least one rule for the care of each tool used in *2* to *5* above.

2. Why are giant trammel points rather than regular trammel points used in the lofting room?

CHAPTER 7

LAYOUT GEOMETRY

NEED FOR GEOMETRY

Why are some of the methods of geometric construction required in layout work? Because it often happens that lines must be drawn or constructed where your tools won't reach. Your squares and protractors need reference edges to start from or to lean against. Furthermore, you can draw a line only as long as the length of their blades. What are you going to do if your straightedge is off a little, or if a large rectangle is to be constructed, requiring lines several feet long?

By using dividers, a straightedge, and geometric construction, you can work on any part of a sheet of any size. And, because all of the angle and shape construction is done on the sheet, you can achieve a high degree of accuracy.

Before you can assemble lines so that they will form a shape, you must determine the angle of intersection of the lines. For example, to lay out a rectangle you need to know how to make the lines intersect at a right angle. Geometric construction enables you to construct any angle so that you can attack all layout problems with confidence.

TO BISECT A LINE

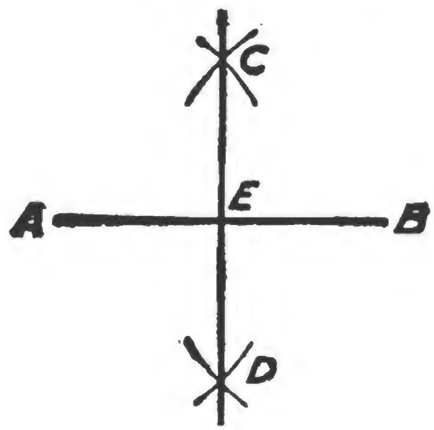


Figure 7–1.

AB is the given line. Take *A* and *B* as centers, and with a radius greater than one-half of *AB*, draw arcs intersecting at *C* and *D*. Then draw *CD*. *E* is the center of line *AB*, and *CD* is perpendicular to *AB*.

TO BISECT AN ARC

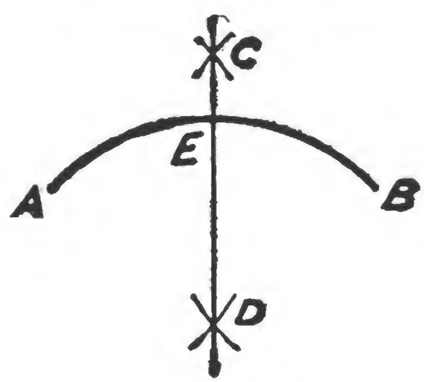


Figure 7–2.

AB is the given arc. Take *A* and *B* as centers, and with a radius greater than one-half of *AB*, draw arcs intersecting at *C* and *D*. Then draw *CD*. *E* is the center point of arc *AB*.

TO BISECT ANY ANGLE

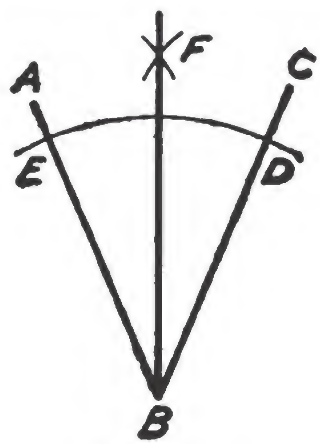


Figure 7–3.

ABC is the given angle. Take *B* as a center, and with any radius, draw an arc cutting the angle at *E* and *D*. Take *E* and *D* as centers, and with a radius greater than one-half of *ED*, draw arcs intersecting at *F*. Then draw line *FB*. Angle *ABF* is equal to angle *FBC*.

TO ERECT A PERPENDICULAR FROM A GIVEN POINT ON A LINE

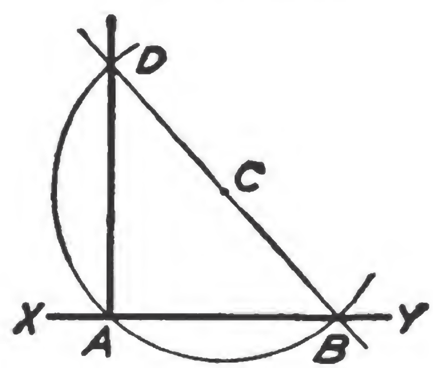


Figure 7–4.

A is the given point on the line *XY*. From any point such as *C*, and with a radius of *CA*, draw the arc *BAD*. Through *B* and *C*, draw a line cutting the arc at *D*. Then draw *DA*, which will be perpendicular to *XY*.

TO DRAW A LINE PERPENDICULAR TO A GIVEN LINE FROM A GIVEN POINT

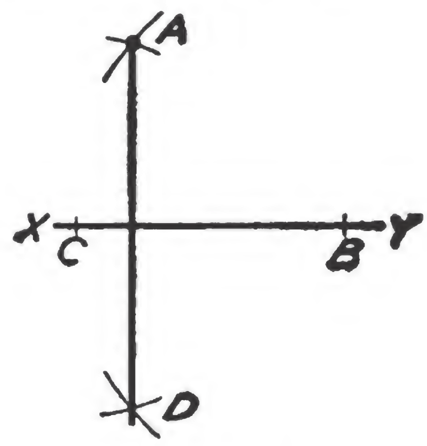


Figure 7–5.

A is the given point; *XY* is the given line. Establish any two points on the line *XY*, such as *C* and *B*. (It does not matter whether *B* and *C* are on opposite sides of *A*, or are both on the same side of *A*.) With *B* as a center, and with a radius of *BA*, draw an arc. Then, with *C* as a center and a radius of *CA*, draw another arc. These arcs intersect at *D*. Draw *DA*. *DA* is perpendicular to line *XY*.

TO DRAW AN ANGLE EQUAL TO ANOTHER ANGLE

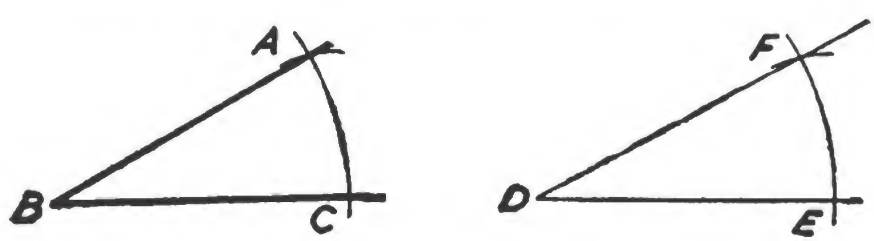


Figure 7–6.

ABC is the given angle. Draw the line *DE*. From points *B* and *D*, draw arcs *AC* and *FE* with the same radius. With *E* as a center, and with a radius equal to *AC*, draw an arc intersecting the arc *FE*. Then draw line *FD*. The angle *FDE* is equal to the angle *ABC*.

TO DIVIDE A LINE INTO ANY NUMBER OF EQUAL PARTS

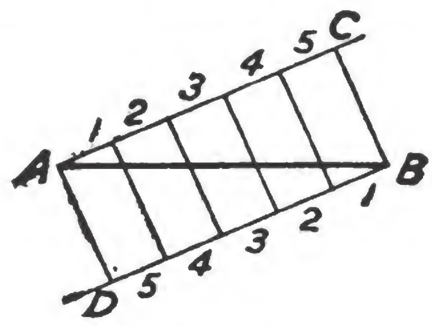


Figure 7-7.

AB is the given line. From *A*, draw line *AC* at any convenient angle and of a length readily divisible into equal parts—say five. From *B*, draw line *BD* so that angle *ABD* equals angle *CAB*. Point off on *BD* the same number of units as on *AC*. Connect the corresponding points on *AC* and *BD*. The connecting lines divide *AB* into five equal parts.

TO DIVIDE THE CIRCUMFERENCE OF A CIRCLE INTO SIX APPROXIMATELY EQUAL PARTS

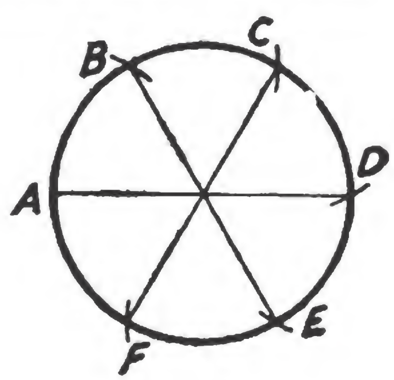


Figure 7-8.

Using the radius of the circle, begin at any point on the circumference, such as A, and draw an arc cutting the circle at B. Then use B as a center to draw an arc cutting the circle at C, and so on around, dividing the circumference into six nearly equal parts. If the points are connected as shown, the lines will form angles of approximately 60° at the center.

TO FIND THE CENTER OF A GIVEN CIRCLE

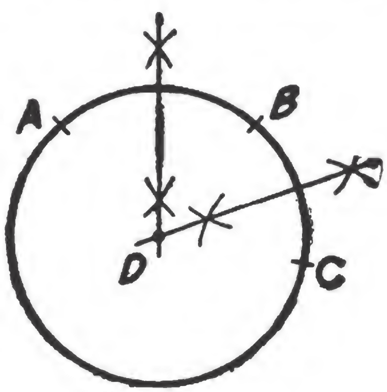


Figure 7–9.

Locate any three points, as A, B, and C, on the circumference of the circle. Bisect the arcs AB and BC. The point D, where the bisecting lines intersect, is the center of the circle.

TO DRAW A SPIRAL

There are two simple methods of constructing a spiral: the point method and the involute method.

The POINT METHOD depends upon swinging gradually increasing arcs from two or more points—the more points, the smoother the curve.

To draw a spiral with a ½-inch space between each turn by the two-point method, first establish points C and D ½ inch apart. With a radius of DC, with D as a center, draw a half circle starting at C and ending at E. Then, using C as a center, and a radius equal to CE, draw another half circle EF, to the left. With D as a center, and a radius DF, swing another half circle, FB. Continue

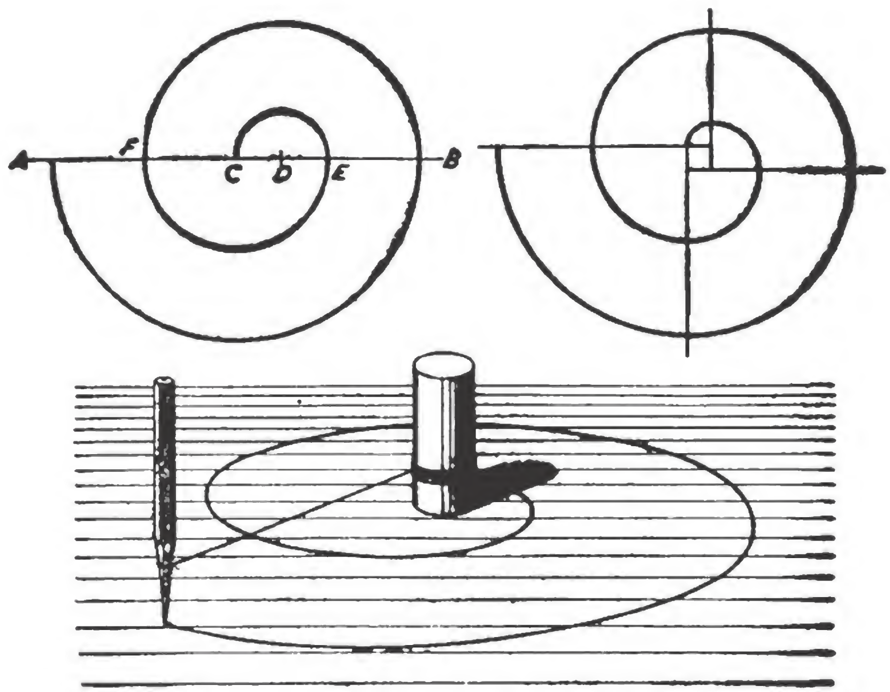


Figure 7-10.—How to draw a spiral.

this procedure until you have the required number of turns.

To draw a spiral with a ½-inch space between each turn by the four-point method, first draw a ¼-inch square with the sides extended as shown in figure 7–10 (upper right). With the upper right-hand corner of the square as a center, and with a radius of one-quarter inch, draw a quarter circle to the right. Then, using the lower right-hand corner of the square as a center, swing an arc with a radius that will make the curve continuous. Use consecutive corners of the square as centers, until you've made the required number of turns.

The INVOLUTE METHOD in theory will permit a perfect spiral. In practice it will permit accurate results if the construction work is carefully done.

To draw a spiral that starts off with any given space between the turns, first select a rod that has a diameter equal to twice the length of the desired turns divided by π. Thus, if there is to be a ½-inch space between turns, the rod should have a diameter of $2 \times \frac{1}{2} \div 3.1416 = 0.318$,

or about five-sixteenths inch. Wrap several turns of string around the rod. Tie the other end of the string to a pencil, hold the rod firmly against the material, and start swinging, as shown in figure 7–10 (bottom). Make sure that the rod and pencil are held perpendicular to the material. Don't let the string wind around the pencil, and don't stretch the string.

For a 2-inch space, you'd use a rod that had a diameter equal to $2 \times 2 \div 3.1416$; for a 3-inch space, $2 \times 3 \div 3.1416$.

ODD ANGLES

It is easy to construct a right angle or an angle of 45°. But how do you construct an angle of $5\frac{1}{2}°$?

First you need to know the radius of the circle, so that you can figure out the circumference. Then, by dividing 360° by the circumference of the circle, you can find the length of the arc for each degree. You can then strike off the required number of degrees for the angle.

Now try this procedure. Suppose the radius of the circle is $7\frac{5}{32}$ inches. The circumference would be $2\pi R$, or $2 \times 3.14 \times 7\frac{5}{32}$, which gives you 44.94 inches as an answer. Unless you're working to extremely close tolerances, you can figure the circumference as 45 inches. Then $\frac{45}{360}$ equals $\frac{1}{8}$, which is the length of the arc for each degree.

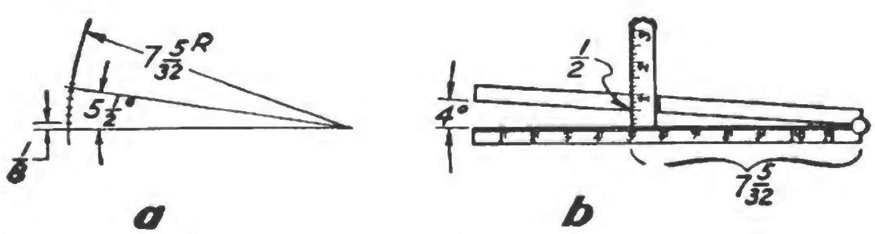


Figure 7–11.—Measuring odd angles.

In *a* of figure 7–11 you can see how to construct the angle. After drawing an arc with a radius of $7\frac{5}{32}$ inches, you can use your dividers to step off $\frac{1}{8}$ inch for each degree, or $5\frac{1}{2}$ steps for $5\frac{1}{2}°$.

This system works fine for stepping off angles up to 15°. But there's a tendency for errors to accumulate if the setting of your dividers is the least bit off. So construct as large an angle as you can by ordinary geometric construction; then add or subtract the extra degrees. For example, if you have to construct an angle of 48°, first construct one of 45°, and then add 3° with your dividers.

For practical working purposes you can determine a small angle by using two rulers and a straightedge, as shown in *b* of figure 7–11. You're using the same basic procedure that's illustrated in *a*, but you're saving yourself some work and some time.

The method shown in *a* is more accurate than that shown in *b*.

ADDED FACTS

Here are some miscellaneous facts about angles.

You can find the circumference of any circle by multiplying the diameter (D), or twice the radius (2R), by π (3.1416).

There are 360° in a circle. A straight line represents an angle of 180°, or one-half of a circle.

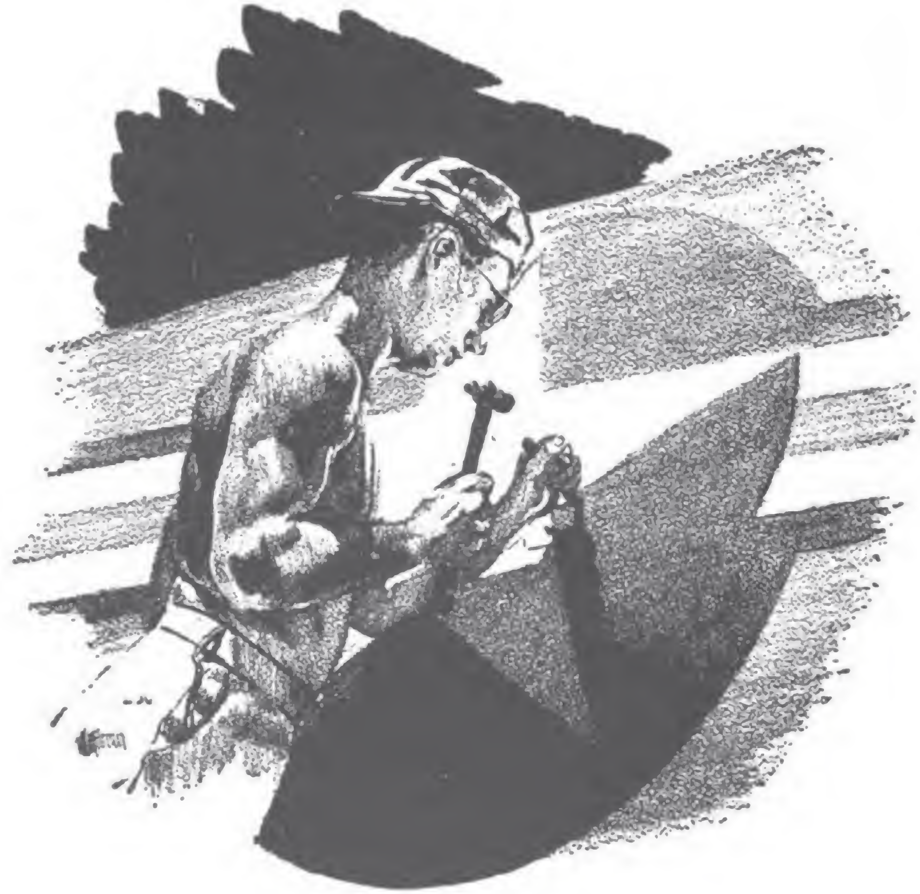
A perpendicular erected on a line forms two 90° angles. Any bisected 90° angle forms two 45° angles.

The radius of a circle will step off six chords on the circumference of a circle. If the ends of the chords are connected through the center of the circle, they will form six 60° angles at the center.

To obtain a 30° angle, bisect a 60° angle. To find a 15° angle, bisect a 30° angle. You can also find 15° by constructing a 45° angle over a 60° angle—the difference between the two angles will be 15°. For practice, take a ruler, compass, and pencil and work out a few angles for yourself. Try to construct one of 20°, one of 58°, one of 110° and one of 165°.

QUIZ

1. Make these constructions without using your square or protractor:
   a. Divide a circle into six equal parts.
   b. Draw an angle equal to one of the six angles formed in *a*, above, without drawing another circle.
   c. Bisect the angle drawn in *b*, above.
   d. Construct a square.
   e. Divide a vertical side of the square in *d* into as many equal parts as there are letters in your first name.
2. If the radius of a circle is 10.75 inches:
   a. How many "steps" will you need in order to measure off on that circle an angle of 9° without using your protractor?
   b. How many inches will the total 9° arc measure?



CHAPTER 8

LAYING OUT

WORKING PLACE

Whenever possible, work on a smooth, flat bench or table. In order to prevent small chips from cutting into the underside of the material, cover the surface with panel board, felt, or heavy paper.

If you have to use a large sheet, ask someone to help you lay it down on the work surface. In handling a sheet, be careful not to bend it. If you have to use a small sheet, you'll get the best results if you lay it down on a metal-surfaced plate.

Cut stock with care and avoid damage to the part you don't need. Leave it in good condition for the next man. If you protect your stock during the layout, you make

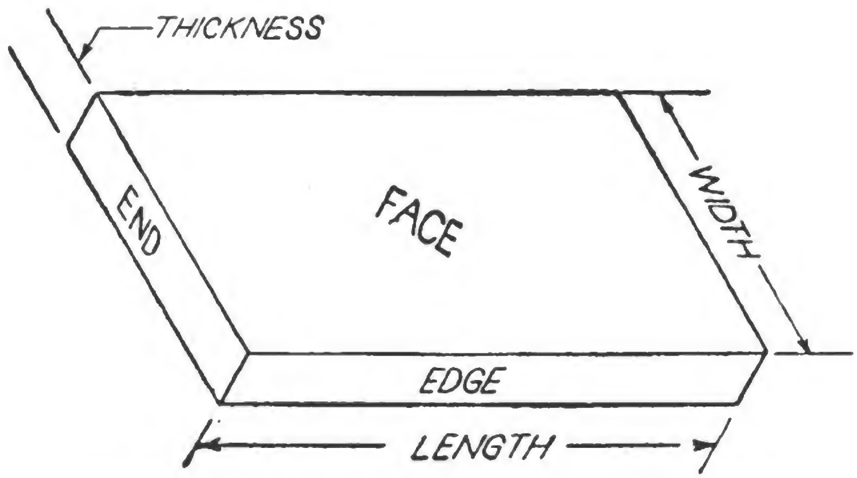


Figure 8–1.—Layout terms for a piece of stock.

things easier for yourself when you finish up the piece.

The layout man calls the surfaces of the stock FACES, EDGES, and ENDS. He also speaks of THICKNESS, WIDTH, and LENGTH. Dimensions are given in that order. Figure 8–1 illustrates these terms.

SQUARE IT UP

Much of your layout work will be done with the combination square. The square won't do an accurate job unless its stock (or head) is held against a straight and square surface. That's why you have to square up one edge and one end of your stock.

Use a 10-inch smooth file to remove the burrs left on the stock when it was cut out. Be careful, because those rough edges can cause a badly cut finger.

Now square one edge of the piece of stock. It must be straight and form a right angle with the layout surface or face. File it until it checks true with the square.

Now square the left end. It must be straight, form a right angle with the layout surface, and be at a right angle with the squared edge.

Don't be satisfied with a half-done job. Those surfaces MUST BE SQUARED. You're going to use them when you lay out all your horizontal and vertical lines.

Watch the corners. It's easy to round them off. Keep them square.

LAYOUT FLUIDS

Layout lines are hard to see on a steel surface unless you use a layout fluid to make them stand out. These fluids furnish a background that contrasts with the scriber lines. They also kill reflection and glare.

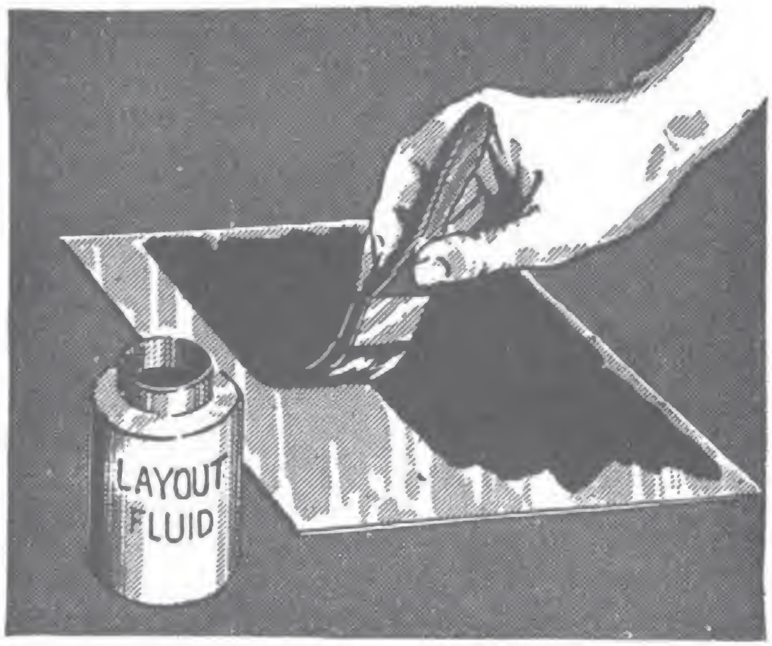


Figure 8–2.—A good background for scribed lines.

LAYOUT DYE

Use layout dye if it's available. It's a purplish blue color, and a thin coat of it dries in 5 minutes.

Layout dye will not work on an oily, dirty, or rusty surface. Clean the surface thoroughly with emery cloth. Apply the dye with a brush, as shown in figure 8–2. Brush it on quickly and don't go over it a second time to "touch it up." Keep it thin.

You can eliminate the brush if you use a small wad of cloth. Dip it in the layout dye and quickly smear it on the surface.

932348°—51——7

ZINC CHROMATE

If you don't have layout dye, use zinc chromate. This is a yellow liquid that dries quickly. Just clean the surface and brush on one thin coat. Let it dry and you have an excellent background for scribed lines.

Zinc chromate prevents rust and corrosion. The Navy uses it extensively as an undercoat for paint and enamel on ships, boats, and planes. You should be able to secure it on any ship or station.

COPPER SULPHATE

You can use a copper sulphate solution on iron and steel. Apply it to the clean surface with a brush or a piece of cloth. A chemical reaction causes a coating of copper to be deposited on the iron or steel.

Don't try to use copper sulphate on aluminum or other non-ferrous metals.

You don't need to use any layout fluid on galvanized iron. Scriber lines will show clearly on the zinc coating.

SIZE UP YOUR JOB

Look at figure 8–3. It's the blueprint of the part you're going to lay out. The part is a small anchor plate fitting used to hold down other parts.

You can see that the holes in this anchor plate are important. Bolts, studs, and shafts will go through these holes into matching holes in other parts. The layout for the holes will have to be extremely accurate, so you'll need a layout procedure that provides the utmost accuracy of hole location.

For some jobs, especially those made of sheet metal or wood, you might use the REFERENCE EDGE method (fig. 8–4). It utilizes the squared edges, but it's not the best method for accurate work.

Another method is the REFERENCE LINE method, also shown in figure 8–4. It starts with an important edge line.

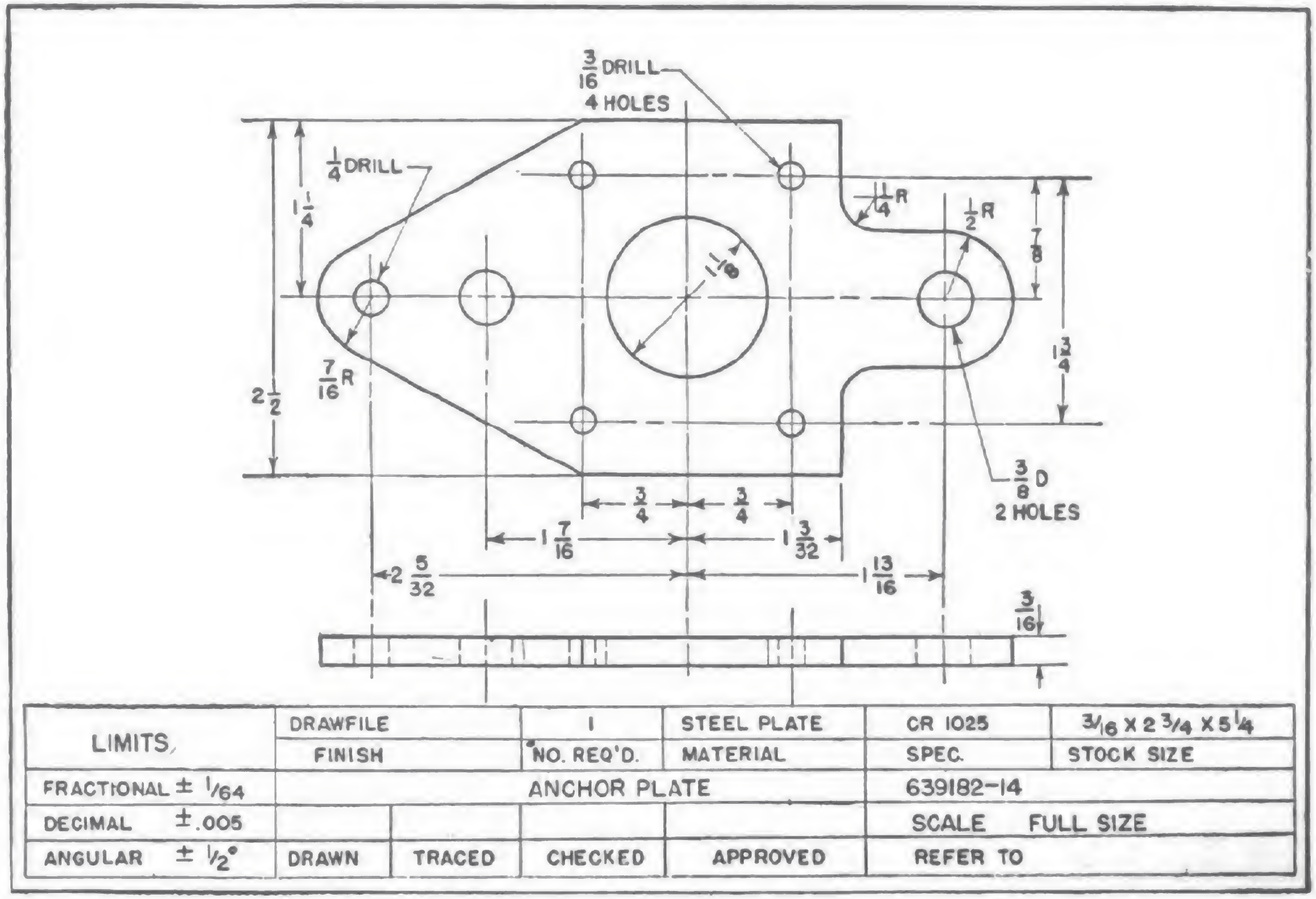


Figure 8-3.—Make a layout of this piece.

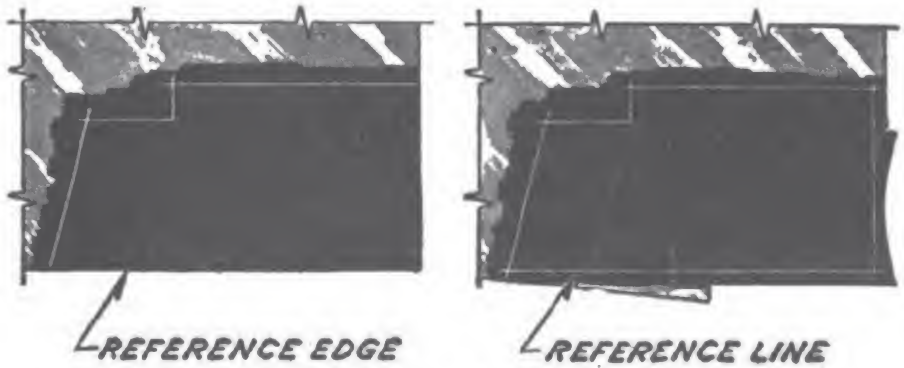


Figure 8–4.—Reference edge and reference line.

You want to start with important centerlines, so you'll use a modification of the reference line method. It's called the basic centerline method and you'll use it to lay out the anchor plate shown in figure 8–3, because it's accurate.

BASIC CENTERLINES

Which centerline is the most important? Which one seems to be the foundation of the drawing, that is, the basis for the other lines? It's the horizontal centerline through the center of the part, the one that passes through the center of four holes. Call it your basic horizontal centerline.

You'll use the other centerline that passes through the big hole for your basic vertical centerline.

All measurements for locating holes will be made from these two lines and from their intersection—the point where they cross.

Now to locate and scribe these two basic centerlines. Place them carefully to avoid running the layout off the surface of the stock.

Look at the dimensions at the left of the top view in figure 8–3. The basic horizontal centerline divides the part into halves, so draw that line through the center of your layout surface. Locate it with your rule and guide the scriber with the square blade. Hold the square stock against the squared end. This line must be parallel to the squared edge.

Now for the basic vertical centerline. How far will you mark it from the left end of the stock?

The distance from the basic vertical centerline to the center of the hole at the left end is $2\frac{5}{32}$ inch. To this dimension add the radius of the arc at the left end, $\frac{7}{16}$ inch. The total distance from the left end to the basic vertical centerline is equal to $2\frac{5}{32}'' + \frac{7}{16}'' + \frac{1}{8}''$ or $2\frac{23}{32}''$.

Hold your rule on edge along the basic horizontal centerline, with the 1-inch mark on the left edge of the stock. Now mark—lightly—at the $3\frac{23}{32}$ inch mark with your sharply pointed scriber. Next, use your square and scriber to scribe the line through that mark. Hold the square stock hard against the squared edge. This basic vertical centerline must be perpendicular to the basic horizontal centerline.

When you're sure both basic centerlines are accurately placed, prick punch their intersection. Your layout should be just like figure 8–5*A*. This point of intersection, labeled *O*, is your BASE POINT for completing the layout. When it's possible to do so, measure from this point to locate other points. This base point is also the center of the large $1\frac{1}{8}$-inch hole.

LOCATE THE HOLE CENTERS

How far from the base point are the two vertical centerlines that help locate the four small $\frac{3}{16}$-inch holes? You'll measure this distance on the basic horizontal centerline on each side of the base point. Here is the procedure:

Set your dividers at three-fourths inch by the rule. Check this setting carefully. Now use the base point *O* for your center, and swing short arcs across the basic horizontal centerline. These arcs locate points *a* and *b*, figure 8–5*B*.

Use the same method to locate the centers for the two $\frac{3}{8}$-inch holes and the one $\frac{1}{4}$-inch hole. In each case, swing the dividers from the basic point *O*. Check your

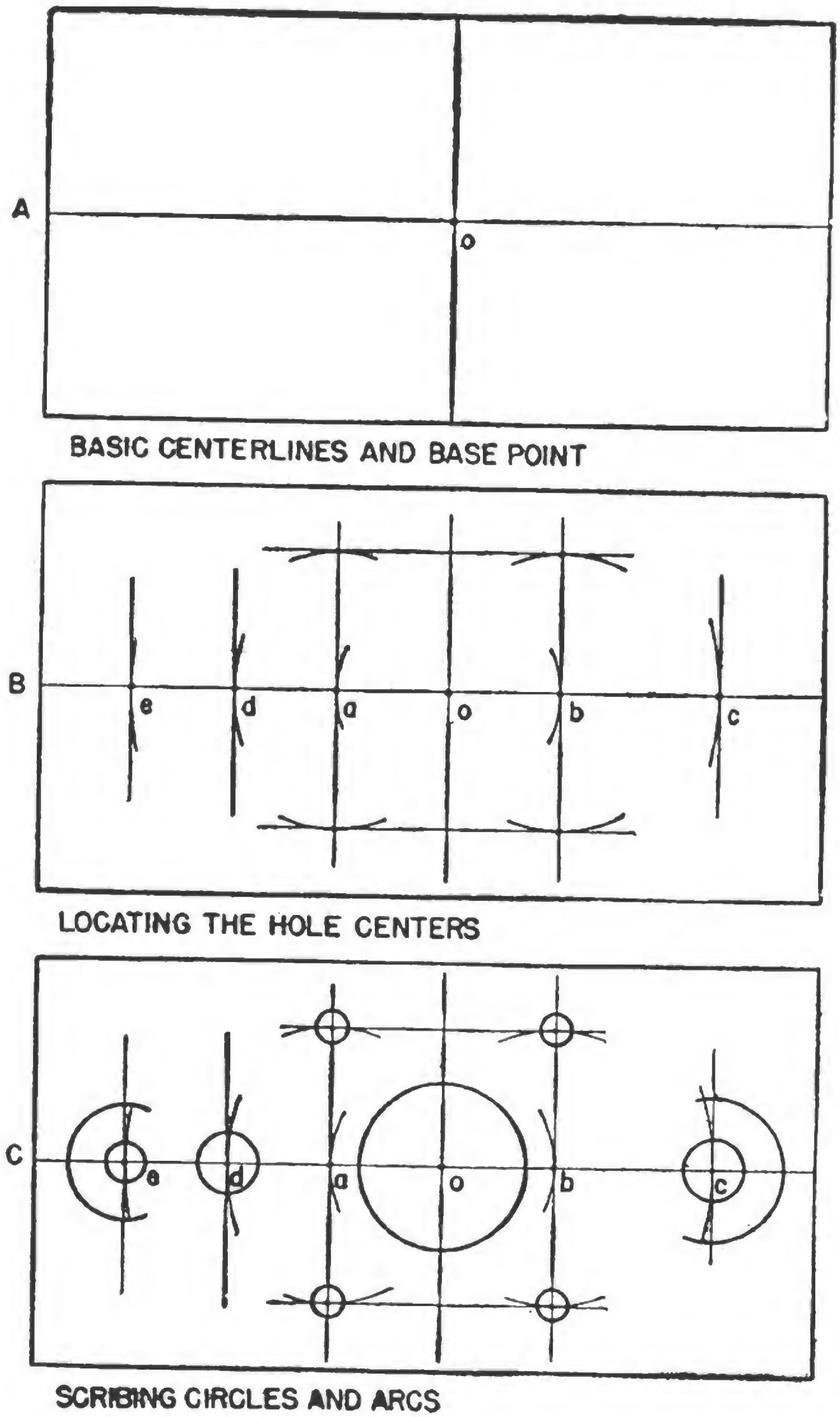


Figure 8-5.—Layout steps A, B, C.

measurements; then use your scriber and square to lay out vertical centerlines through the intersections. Now prick punch these intersections, *a*, *b*, *c*, *d*, and *e*.

Next, get the two horizontal centerlines for the four $\frac{3}{16}$-inch holes. The dimension shows these lines to be seven-eighths inch from the basic horizontal centerline. Set your dividers for seven-eighths inch and swing arcs from centers *a* and *b*, as shown in figure 8–5*B*.

Connect these arcs with TANGENTS (straight lines) to form the two centerlines. Prick punch the hole centers. At this point your layout should look like figure 8–5*B*.

Scribe in the holes and swing the two end arcs. Check each arc radius carefully. It's good layout practice to start with the smallest radius and end with the largest.

Your layout should now correspond to figure 8–5*C*.

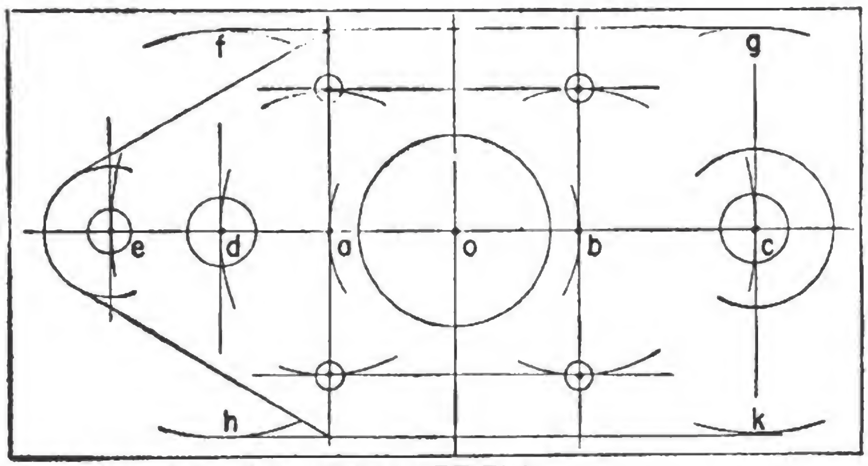
FINISH THE OUTLINE

You have part of the outline—the arcs at the ends of the anchor plate. How can you accurately lay out the remainder of the outline?

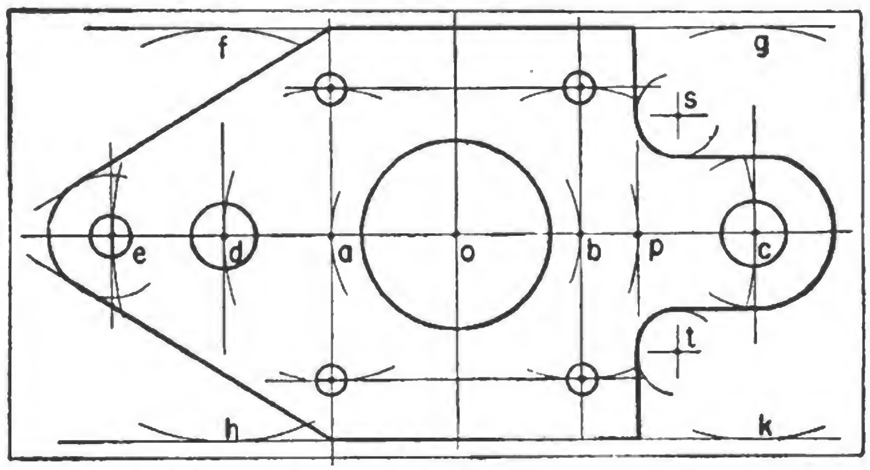
First get the top and bottom outlines. Set the dividers for $1\frac{1}{4}$ inch and swing arcs *f*, *g*, *h*, and *k* from centers *c* and *d*, as in figure 8–6*D*. Then scribe the tangent lines through these.

The next step is the slant lines of the left end. Each one is tangent to the left end arc and runs through the intersection of the horizontal outline and the vertical centerline through point *a*. Line up your rule so that the edge passes through that point and is tangent to the arc. Scribe the lines in, and your layout should be like figure 8–6*D*.

The vertical lines forming the right end outline are located by setting the dividers at $1\frac{3}{32}$ inch and swinging the arc through point *p*. Scribe the line through this point of intersection. It is perpendicular to the basic horizontal centerline. The short horizontal lines of the right end outline are scribed in tangent to the arc and parallel to the basic horizontal centerline.

D


OUTSIDE OUTLINES, LEFT END

E


THE COMPLETED LAYOUT

Figure 8–6.—Layout steps *D* and *E*.

Now locate the centers for the two ¼-inch radii at *s* and *t* and swing these arcs to complete your layout. It should be just like the completed layout shown in figure 8–6*E*.

It's time for a checkup. Check all dimensions for accuracy. Check the radii of the arcs and circles. Check all right angles to make sure they're exactly 90°.

Even if you're satisfied that it's right, you should get an experienced layout man to give it an additional check. If your lines are off more than a few thousandths, he can point out the errors. If the layout expert approves it, you're on your way as a layout man. If not, turn the

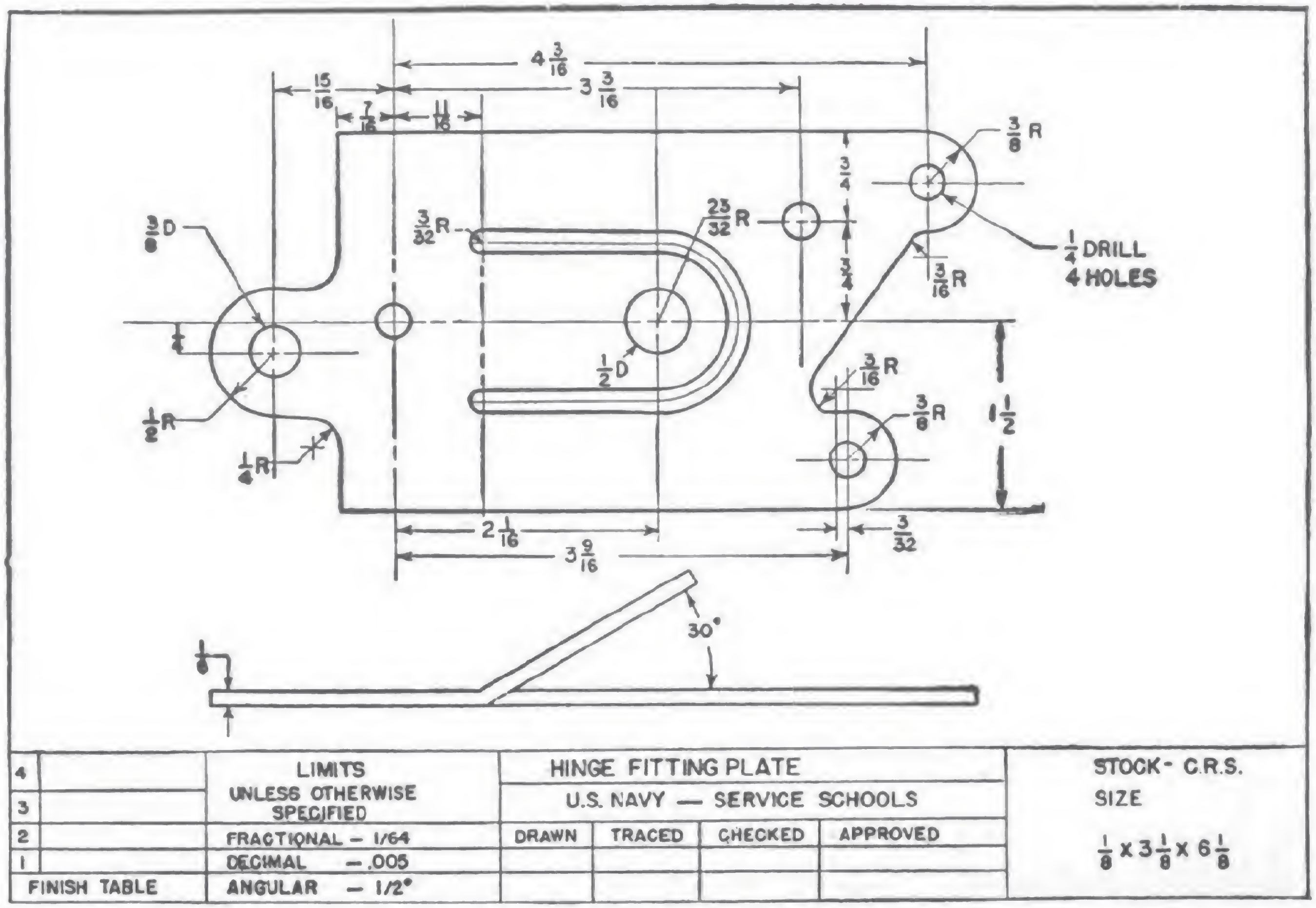


Figure 8-7.—Practice layout problem.

layout over and make a fresh start on the other surface. That old rule, PRACTICE MAKES PERFECT, certainly applies to layout work.

SAFETY RULES

Under conditions of stress and prolonged vibration (present in all aircraft), a scratch will focus strains, causing the scratch to deepen until finally the metal snaps. A scratch will often break protective coatings and hasten corrosion.

Unnecessary scribe lines are no better than any careless, harmful scratch. Unless the scribe lines are to be cut or punched out, or are required for very close tolerances, it is best to use a pencil for points and lines.

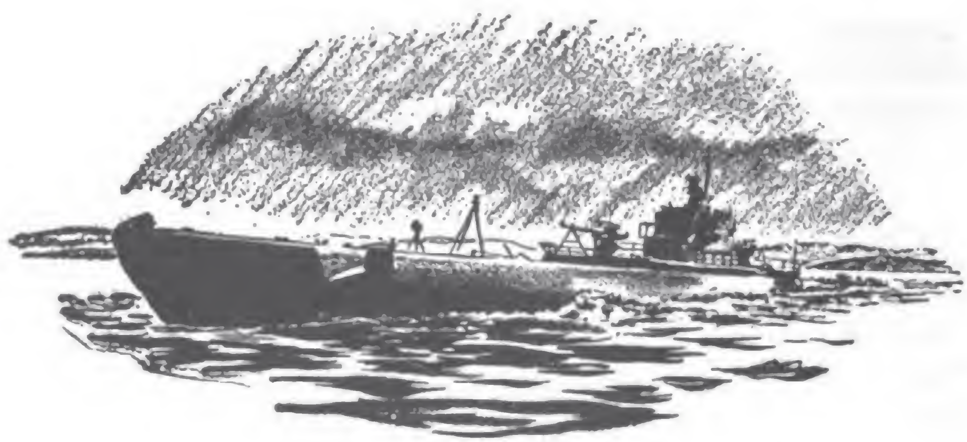
Don't allow your layout tools to float around on the bench top with the files, hacksaws, drills, and hammers. Remember that your layout tools are precision tools and must be handled with extreme care.

PRACTICE LAYOUT

Try laying out the part shown in figure 8–7. Use the same system that you used for the anchor plate.

QUIZ

1. Accuracy of a layout is partly dependent on the correct use of the combination square. What condition of the stock must exist before the square can do an accurate job?
2. What is the chief purpose in using layout fluid?
3. How does a reference line differ from a reference edge?
4. What is the correct procedure method for laying out the anchor plate, figure 8–3?
5. List two uses of prick punch marks.
6. Why should pencil marks be used instead of scratches when the points or lines are not to be punched or cut?



CHAPTER 9

CURVE OR BEND ALLOWANCE

WHAT IS BEND ALLOWANCE?

You'll see curves practically every time you see a bend line on a blueprint. Bending is the forming operation most frequently used in aircraft construction. Unless you know how to master the curve in bent metals you will always have trouble in your layout work.

First of all, you must realize that a curved corner takes less metal than a square corner. The problem is to figure out how to cut the stock the right length before you bend it. This is where you'll need to know the BEND ALLOWANCE (abbreviated B.A.), that is, how much metal to allow for each bend.

Figure 9–1 illustrates what happens to metal when it's bent. In *a* you see a fairly thick sheet of metal with perpendicular lines drawn across the edge. What happens to the metal when it's bent to a 90° angle? The answer to that question is shown in *b*. Notice that the lines drawn across the straight portions of the edge of the sheet have not changed. But the lines drawn across the bent edge of the sheet converge at a point inside the curve—at the radius point of the inside curve.

The lines closer together indicate that the metal has been compressed along the inside curve.

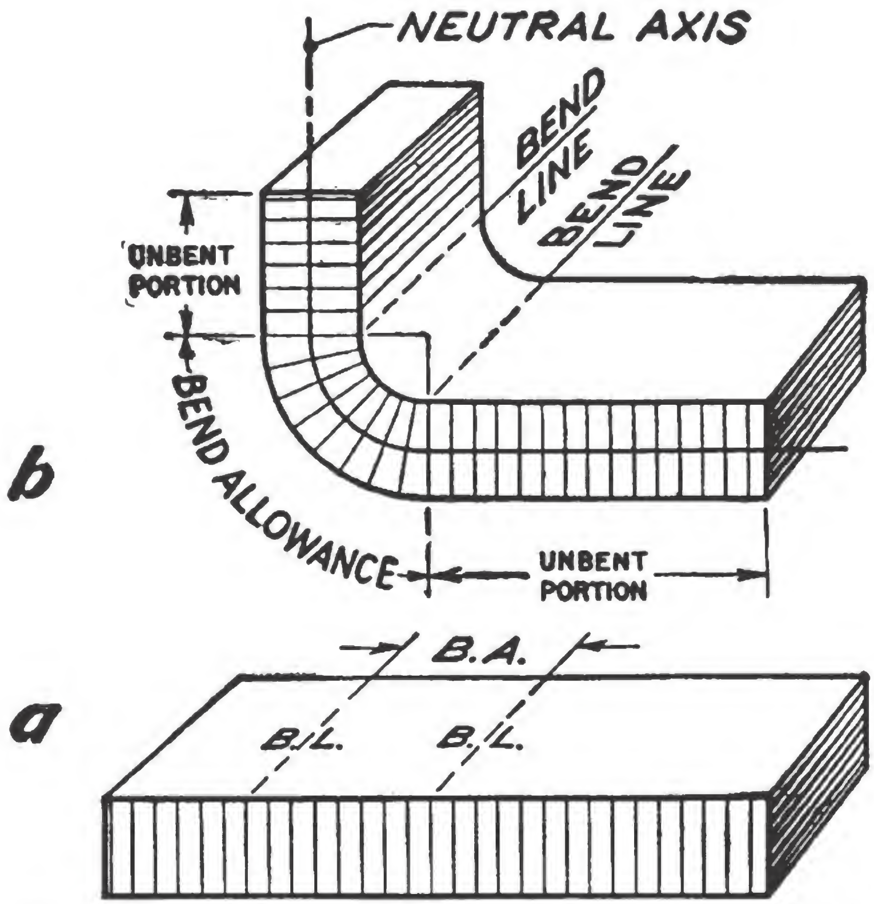


Figure 9-1.—This is what happens to metal when it's bent.

The lines farther apart indicate that the metal has been stretched along the outside curve.

If the material has been compressed along the inside curve and stretched along the outside curve, there must be points somewhere between where there is neither compression nor stretching.

They occur where the width of the spaces along the curve equals the width of the spaces along the unbent portions. When all these points are joined, you'll see an inner curve, represented in *b* by a line called the NEUTRAL AXIS.

Notice that the neutral axis is halfway between the inside and outside surfaces.

The neutral axis has not changed in length. Therefore,

it represents the ACTUAL LENGTH of the material to be used.

The curved portion of the neutral axis represents the length of material allowed for the bend, that is, BEND ALLOWANCE.

HOW IT WORKS

Here's how to figure the B.A. for the problem shown in figure 9–2.

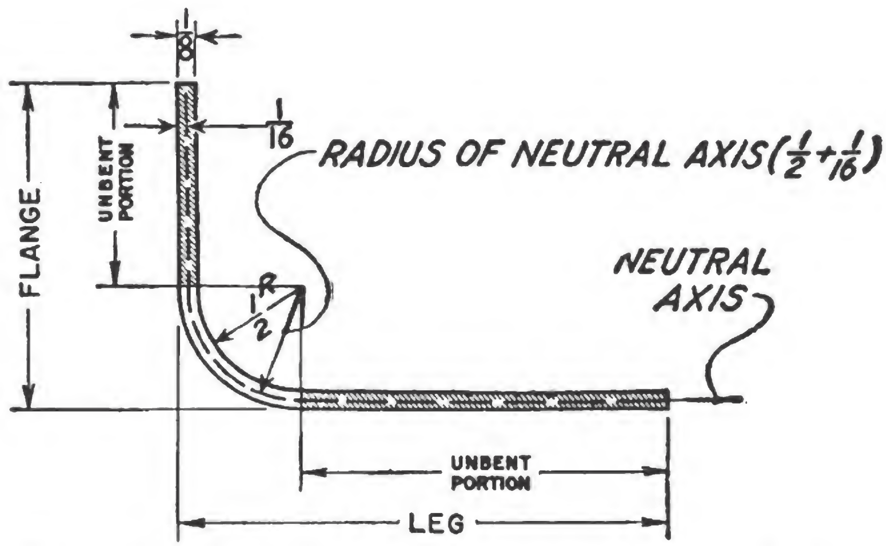


Figure 9–2.—You'll have to figure B.A. for angles like this.

You know that the true length of the bent stock can be found along the neutral axis. So your first job is to find the radius of the neutral axis. You can do this by adding the inside radius of the stock and one-half of the stock thickness, as—

$\frac{1}{2} + \frac{1}{16} = \frac{9}{16}$ = RADIUS OF NEUTRAL AXIS

What's an angle? Right angle, or 90°, or one-quarter of a circle (90/360). By finding the circumference of a circle with a $\frac{9}{16}$-inch radius, then dividing by 4, you'll find the B.A.

Before you can work this out, you'll have to find the decimal equivalent of the fraction $\frac{9}{16}$. Referring to Appendix IV, you find that it is 0.5625.

Now you can set up your equation:

$$\begin{aligned} C &= 2\pi R \\ &= 2 \times 3.1416 \times 0.5625 \\ &= 3.5343 \\ \frac{C}{4} &= \frac{3.5343}{4} = 0.88332 \end{aligned}$$

First of all, notice that the stock thickness and the radius are given, as well as the leg and the flange.

$$\text{B.A.} = 0.88332, \text{ or } \tfrac{57}{64}$$

To determine the lengths of the unbent portions, subtract the stock thickness and the inside radius from the leg and the flange.

$3 - (\frac{1}{2} + \frac{1}{8}) = 2\frac{3}{8}$ = UNBENT PORTION OF LEG
$2 - (\frac{1}{2} + \frac{1}{8}) = 1\frac{3}{8}$ = UNBENT PORTION OF FLANGE

Now add to the sum of the unbent portions the B.A., as—

$$2\tfrac{3}{8} + 1\tfrac{3}{8} + \tfrac{57}{64} = 4\tfrac{41}{64}$$

That's the length you should measure off on the stock before cutting.

After you've solved this problem, compare the sum of the leg and flange to the length you're going to cut. It's 5 inches against $4\frac{41}{64}$ inches. So you can see that a curved corner DOES require less metal.

HERE'S A PROBLEM

You've worked out the B.A. for a right angle (90°). Here is how you get the B.A. for a 36° angle:

Assume that you have the same stock thickness, radius, leg, and flange as shown in figure 9–2. But instead of a 90° angle you have a 36° angle.

Using the method you've just learned, your first step is—

$$
\begin{aligned}
C &= 2\pi R \\
&= 2 \times 3.1416 \times 0.5625 \\
&= 3.5343 \\
36/360 &= 1/10 \\
\frac{C}{10} &= \frac{3.5343}{10} = 0.35343 \\
\text{B.A.} &= 0.35343, \text{ or } 23/64
\end{aligned}
$$

Then, adding the B.A. to the unbent portions, you get—

$$2\tfrac{3}{8} + 1\tfrac{3}{8} + \tfrac{23}{64} = 4\tfrac{7}{64}$$

BEND ALLOWANCE TABLE

The direct calculation method of finding the B.A., which you've just learned, is easy to remember, easy to figure, and accurate enough for most work. But you must realize that the B.A. you obtain by that method is only approximate, because the metal does not compress and stretch in equal amounts.

For more accurate work you should use a B.A. table.

A B.A. table has been computed from an empirical formula, that is, a formula that has been developed by trial-and-error experimentation and found to yield a dependable solution. A table of this kind takes into consideration the fact that metal does not stretch exactly as much as it is compressed.

To use a B.A. table, first locate the thickness of the metal (T) in one column, and the radius (R) in the other column. The factor given is the B.A. for one degree. Then multiply that factor by the number of degrees in the bend.

To find the B.A. for the problem shown in figure 9–2, turn to Appendix V, the B.A. table for aluminum alloys:

The stock thickness of one-eighth inch (0.125″) equals approximately the tabular value of 0.128 inch. Following down that column in the table to ½″ you find that the factor is 0.00971.

To find the B.A. for 90°—

$$90 \times 0.00971 = 0.8739, \text{ or } \tfrac{56}{64} \text{ inch}$$

(That's one sixty-fourth inch less than the answer you got by the direct calculation method.)

Don't forget to add the B.A. to the sum of the unbent portions.

Just as a check, see what you get for the B.A. of the 36° angle.

$$36 \times 0.00971 = 0.34956, \text{ or } 22/64$$

(Again you have 1/64 inch difference between the direct calculation method and the B.A. table.)

There are B.A. tables for steel and other metals as well as for aluminum alloys.

SET BACK DEVELOPMENT CHART

A set back development chart is also based on an empirical formula. (See Appendix VI.) To use this chart, you'll have to be able to tell the difference between a closed angle and an open angle. (A 90° angle is neither closed nor open.)

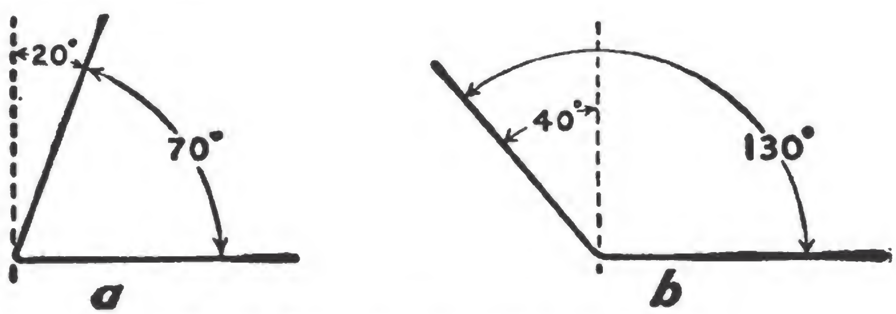


Figure 9-3.—Closed and open angles.

Compare the two angles shown in figure 9-3. The dotted line represents a 90° angle. Notice that the closed angle leans toward the leg. The angle is 70°—or 20° closed (90° − 70° = 20°). The open angle leans AWAY from the leg. The angle is 130°—or 40° open (130° − 90° = 40°).

In figure 9-4 you see an angle of 140°—or 50° open.

The stock thickness of the bend is 0.064. And the radius is 1/8, or 0.125 inch. What length should the stock be cut?

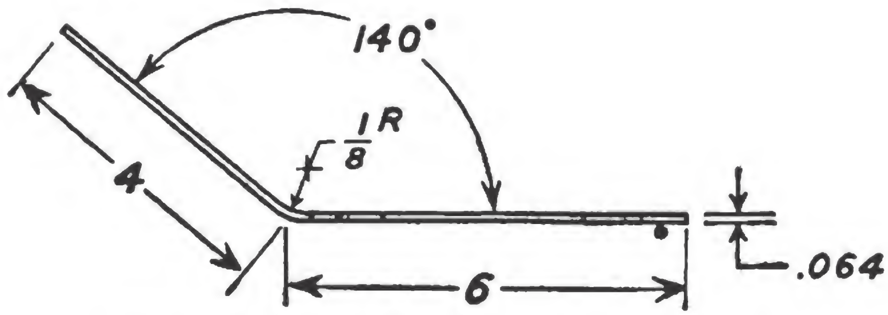


Figure 9-4.—Find the set back for this angle.

Look at the chart, appendix VI. Place your ruler or steel edge on the chart so that it lines up with the bend radius, 0.125 (top), and stock thickness, 0.064 (bottom). Notice that the heavy horizontal line represents 90°. You're looking for the amount of set back for an open angle, so look below the heavy line. Find 50° and follow the line from 50° horizontally across the chart until it intersects your ruler at a point along a curve. Then follow the CURVE. You should get 0.030 for your answer. This represents 1/32 inch.

The sum of the leg and flange of the bend is 6 + 4 = 10. Subtract: 10 − 1/32 = 9 31/32. You should cut the stock to that length.

You can use the set back development chart only for angles open up to 60°, or closed to 60°.

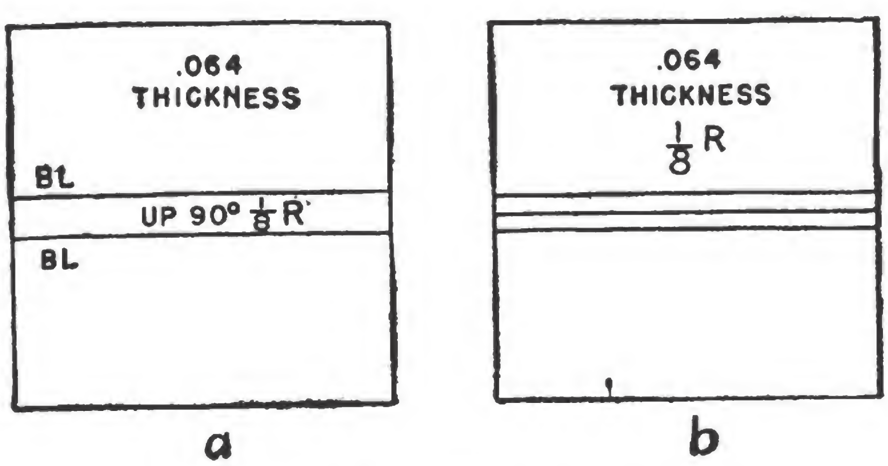


Figure 9-5.—Angles in the flat.

WHAT'S A MOLD LINE?

In *a* of figure 9–5 you see a blueprint of a bend as it is laid out in the flat. For this type of drawing you are expected to use a B.A. table.

For a drawing like *b*, you'll use a set back development chart.

The chief difference between these drawings is this: in *a* you can determine the measurements of the unbent portions, using the method shown earlier in this chapter; in *b* your strategy depends upon knowing what a mold line is and where it is.

A MOLD LINE is a theoretical edge that would be formed by extending the surfaces so that they intersect. You can

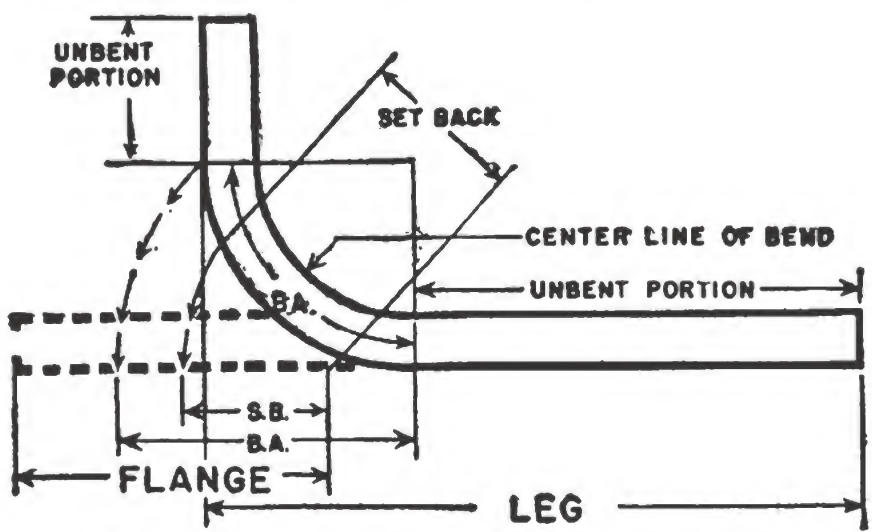


Figure 9–6.—Mold line and tangent bend lines.

understand the principle of the mold line by studying figure 9–6.

From the visual explanation you can readily see that the leg plus the flange minus the set back will give you the correct length of the stock.

SOLVING B.A. FOR MORE THAN ONE BEND

How would you solve the B.A. for a part that had four bends? In figure 9–7 the problem is worked out for you.

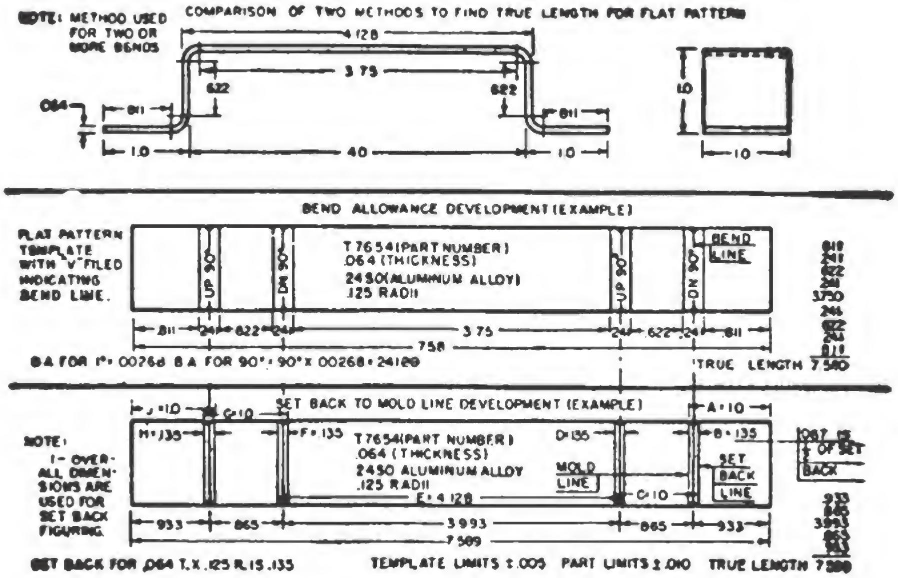


Figure 9-7.—Compare the two methods.

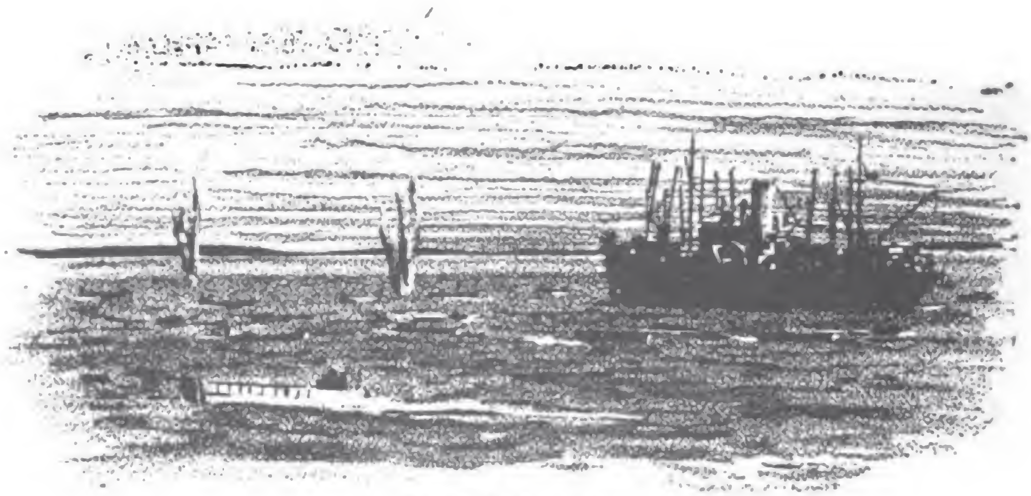
In one illustration the allowance table has been used; in the other the set back development chart has been used. If you have difficulty trying to figure out just what some of the numbers are, don't forget that they may have come either from the table or from the chart.

BENDING MACHINES

In working in the shop you'll discover that there are numerous ingenious machines that will solve your bending problems automatically—such as radius bars, die brakes, corner brakes, flange machines, and box brakes. But there will be times when you'll have no machines, and then you'll be thankful that you know how to figure the B.A.

QUIZ

1. There are two tabular means of computing the amount of metal to be allowed for a curved corner. Which of these means has for its last step?
   a. Addition of tabular answer to the sum of the unbent portions of the metal?
   b. Subtraction of tabular answer from the sum of the leg and flange?
2. Are the following angles closed or open? How much?
   a. 10°. c. 125°.
   b. 179°. d. 90°.
3. What surfaces would have to be extended to establish the theoretical edge called a mold line?



CHAPTER 10

TEMPLATES

ACCURACY REQUIRED

The measurements on templates MUST BE ACCURATE. The template is made first and is used in production work as a guide for making a number of duplicate parts. If it's wrong, all parts made from it are wrong.

The procedure followed in making a template is essentially the same as that used in making a layout. Templates are usually made of sheet steel, to withstand the wear and tear of shop use. But in spite of the sturdy metal, templates become damaged or inaccurate from use. Don't work with an inaccurate template. Get out the blueprint and make a new template.

Since you are going to be working in meta' to limits of ± 0.010 or ± 0.003 inch, you'll have to have a magnifying glass. No guesswork is permitted when you make templates.

You can't use a pencil or a pencil compass, because neither makes a sufficiently sharp outline. For all template work you'll use scribers and dividers, to make the sharpest outline possible. And for further accuracy you'll use your magnifying glass—to transfer dimensions from scales, to set dividers, and to check up on the accuracy of scribed lines.

MAKING A TEMPLATE

In making a template you'll need to figure the B.A. if the part has a bend. The man who makes a part from your template wants to be sure you figured the B.A. before he starts cutting the metal. The geometric construction and B.A. are all a part of the usual layout job. But you'll vary the layout procedure slightly.

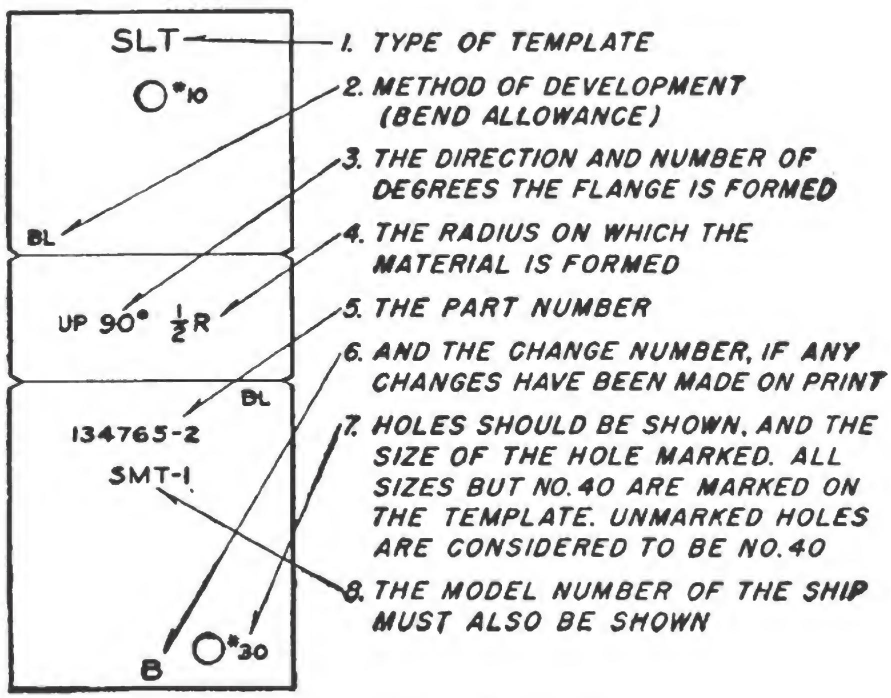


Figure 10–1.—Template.

In the first place, this is one time when you're expected to mark on the surface.

Study figure 10–1. The information and instructions listed are all a part of a template. They're there so that anyone can make a part simply by reading the directions.

"SLT" is an abbreviation for steel layout template.

"BL" is an abbreviation for bend line.

Notice that two notches have been cut into the template on the left-hand and right-hand edges. They're there to help you transfer the BL's to the work. The rest of the information is self-explanatory.

HOLES

In order to achieve the highest degree of accuracy, the holes in template work are punched. They are never drilled. The purpose of the template holes is to specify location, not size. For this reason a punch of a specific diameter—either 1/8 inch or 9/32 inch, depending upon instructions—can be used for all the holes.

When transferring hole locations from the template to the work, use a transfer punch. This punch will fit exactly in the punched hole on the template. When you strike it with a hammer, you'll make a center punch mark on the work underneath.

Once you have a center punch mark, you are ready to start drilling. The diameter of the drill you should use is given on the face of the template.

BEND RELIEF HOLES

Wherever bends intersect, there's some strain on the metal. If some provision isn't made, the metal will eventually tear or crack.

This danger can be avoided by locating a relief hole at the intersection of bends. It is then possible to cut away the material at the intersection so that the flange and leg will be independent of each other. By doing this you can avoid strains on the metal where the bends meet.

There are several types of relief holes (fig. 10–2). Blueprints will always specify which type you should make.

In *a* the relief hole is located at the intersection of the inside bend lines. The diameter of the hole is usually calculated as being four times greater than the thickness of the metal. This type of relief hole is particularly effective when rivets or bolts have to be put close to corners.

In *b* the radius point is at the intersection of the centerlines of the two sets of bend lines. You'll probably use this type of relief hole more frequently than any other.

In *c* the point for the radius is at the intersection of

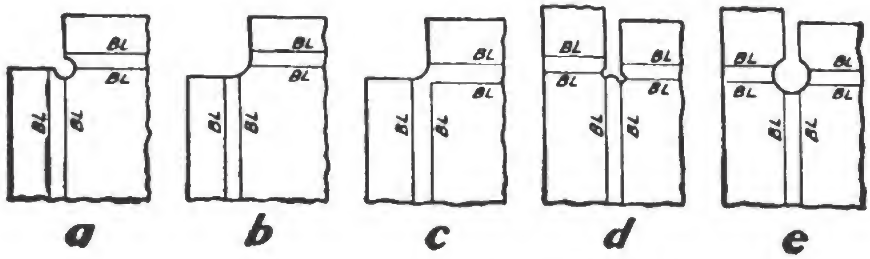


Figure 10–2.—Types of relief holes.

the two outside bend lines. This type of relief hole can be used only on soft stock; it's especially good for watertight construction that does not require welding. Such a corner may be used to make compartments watertight, by placing a compound-saturated cloth over the hole; or it may be used in a corner where stringers or stiffeners come through a bulkhead.

In *d* three bends meet.

In *e* you see the same problem, but the hole has been modified. It's easier than the method shown in *d*. Simple fabrications also keep construction time down.

TABS

Occasionally you'll be able either to save time or prevent the loss of a template by putting tabs on the template.

For instance, the template shown in figure 10–3 has two tabs. The large tab has a hole, drilled especially to take the pilot of a sheet metal punch. This punch has a

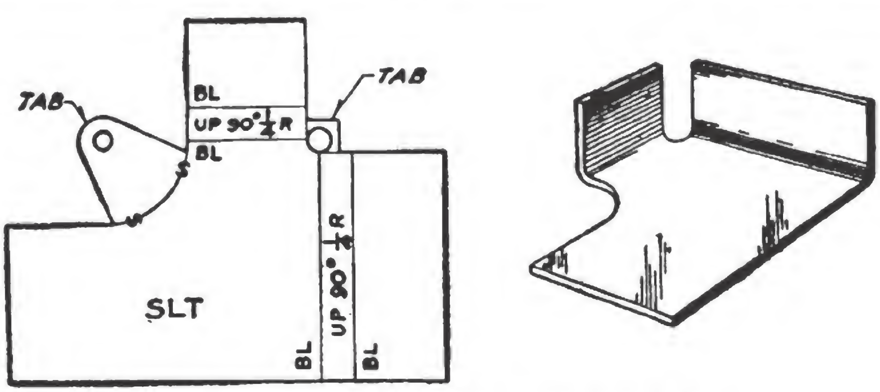


Figure 10–3.—Template with two tabs.

curved edge which will cut out the radius in one operation.

When you see the letter *S* in a line, you should cut along that line. The *S* stands for SHEAR.

The small tab is useful, too. You can use it to center a drill or punch for making the small radius. After the hole has been made in the sheet, you can make straight cuts, leaving the radius clear.

Before you make a tab of this kind, check up on your equipment. You'll need special tools for the punching and drilling.

The perspective drawing shows the part as it would be made. The tabs have been removed.

The template shown in figure 10–4 is mostly tab.

A small template is hard to work with and is easily mislaid. But a large tab lets you get a good hold on the template, so that you can keep it in position when scribing around it.

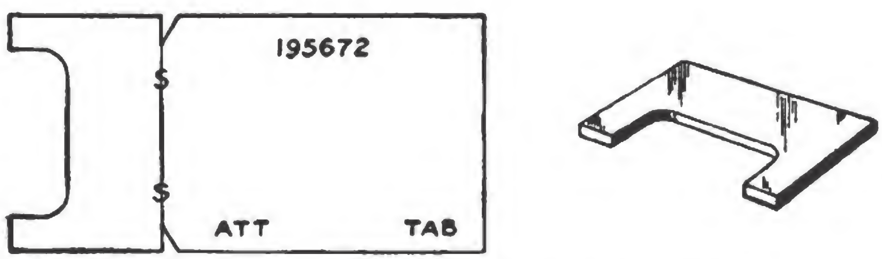


Figure 10–4.—Template with large tab.

Because there's more room on the tab than on the template, the template information has been put on the tab.

MORE THAN ONE

In laying out a template that has more than one flange, first select a base—usually the largest section of the final part. The base shown in *a* of figure 10–5 is the section, *A*, to which the flanges are attached. Then add the B.A.'s as shown in *b*. Next add the two flanges. Notice that a small tab is indicated. That's to make sure that the relief hole is properly positioned.

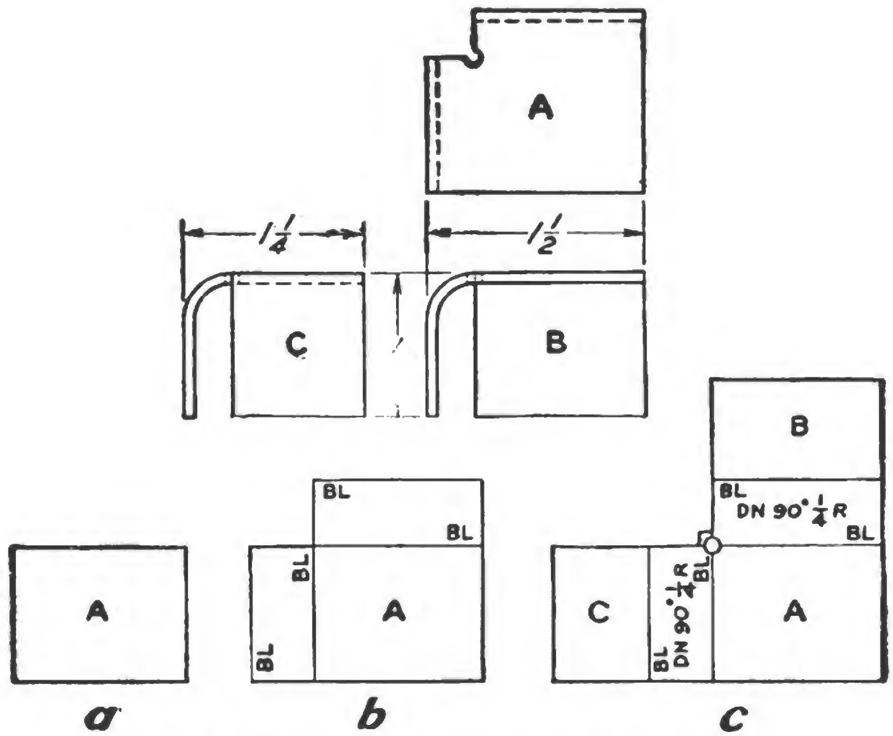
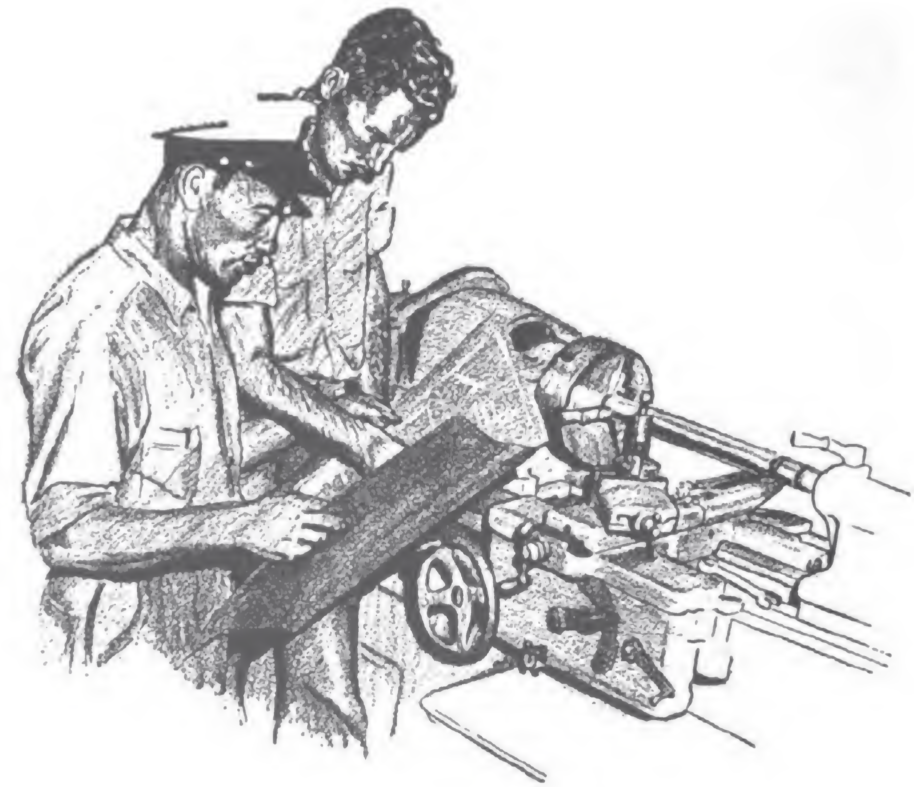


Figure 10–5.—Template with more than one flange.

When you transfer BL's and centerlines to your work—in fact, any line that will not be removed by cutting—use a pencil.

QUIZ

1. What do relief holes relieve?
2. a. Why are templates made to such close tolerances?
   b. Name three rules for template-making which are intended to insure accuracy.
3. What should you do if you find a template has become inaccurate from use?



CHAPTER 11

DEVELOPMENTS

UNROLL IT

In chapter 2 you were told that curved surfaces have to be laid out IN THE FLAT before they can be rolled, bent, or otherwise formed into the desired shape. The process of laying out for sheet metal objects is generally referred to as SHEET METAL DEVELOPMENT. The layout development can be made directly on the sheet metal surface; or you can develop a paper pattern and transfer the development to the metal sheet.

ANGULAR DEVELOPMENT

The simplest form of angular development is illustrated in figure 11-1. It's a plain box with a rectangular bottom and straight sides. The principles involved are easy to understand—but what layout procedure will you use?

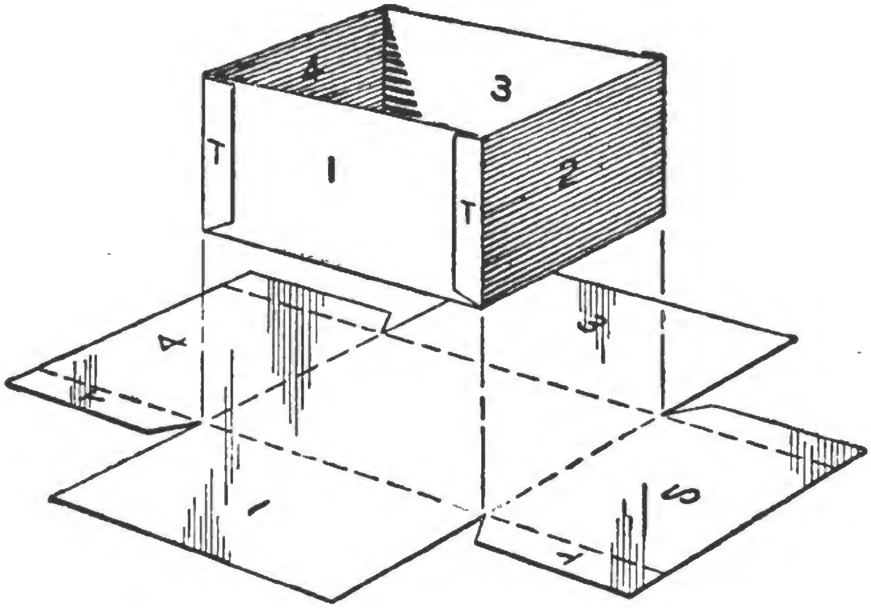


Figure 11-1.—Angular development of a box.

One method is to square the sheet metal stock to the exact over-all dimensions and then lay out all other lines from those square edges and ends.

An alternate method is based on the use of two perpendicular centerlines. All measurements are made from them. Follow the procedure that you used for the anchor plate layout.

For most box layouts made on paper you need to develop only one-fourth of the pattern. This quarter-pattern is cut along the centerlines and transferred to the metal by lining up the centerlines of the pattern with centerlines on the metal. But don't forget those laps or tabs, indicated by *T* in figure 11-1. They provide a means of fastening the box together. Be extremely careful when you cut out a developed pattern or you may snip off one of the tabs.

It's easy to make an angular development like that shown in figure 11-1; but laying out the development of the flared-end box shown in figure 11-2 isn't quite so simple. Try it for practice, using the following procedure:

First, secure a piece of heavy paper about 2 feet square.

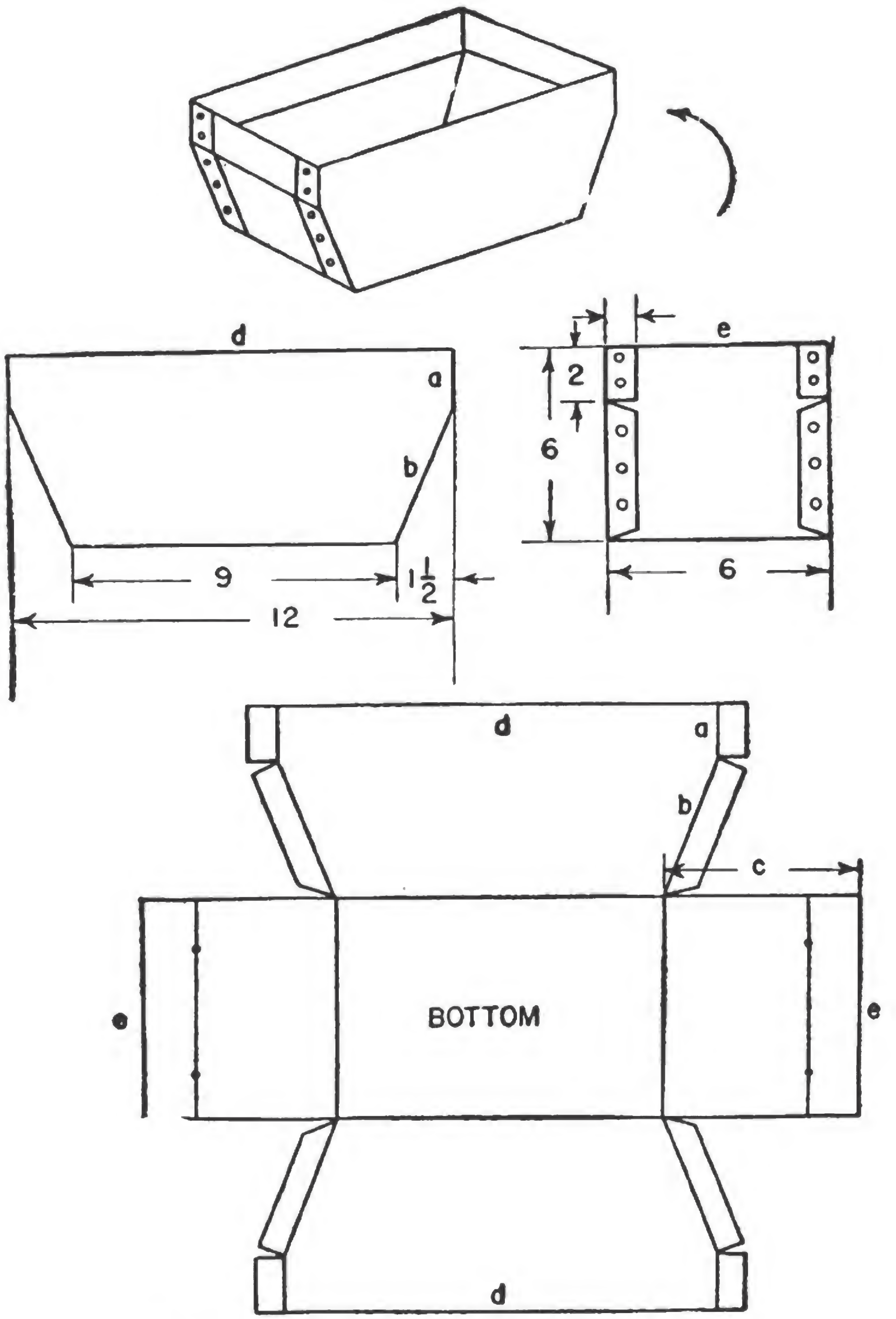


Figure 11-2.—Development of flared-end box.

Then break out your layout tools and find a flat surface to work on.

Start with the bottom. It's 6 inches by 9 inches. Measure and lay out carefully, making sure that the corners are right angles. Now locate and mark the outside lines marked *d*—they're 6 inches from the bottom lines, and they extend $1\frac{1}{2}$ inches past the bottom lines at each end.

Lay out lines *a* and *b* for each corner. Extend line *c* and locate line *e*. Here's the "booby trap" of this layout. Line *e* is not 6 inches from the parallel bottom line—it's more than 6 inches. Look closely at the picture of the box and you'll see that line *c* is equal to the length of line *a* plus the length of line *b*. Check this part of the development carefully.

When you have finished the main outline, lay out the tabs and mark the bend lines. Check all your measurements. Then cut out the pattern and form it up to test the accuracy of your development.

If the ends and sides are FLUSH along their edges, you have successfully completed a type of angular development that is often used.

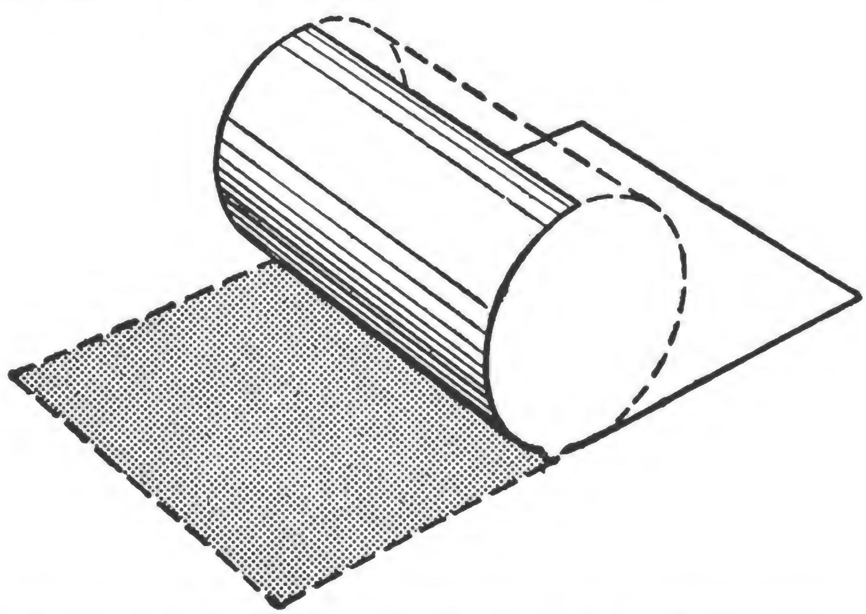


Figure 11-3.—Cylinder roll-out for parallel development.

PARALLEL DEVELOPMENT

Making a development for a plain sheet metal cylinder is just like unrolling a rug. And once you know the diameter, all you have to do is figure the circumference (πD) and allow extra metal for the seams. Figure 11-3 shows the principle of laying out a cylindrical object by a parallel development. It's very simple—but how about the cylinder that has been cut at an angle?

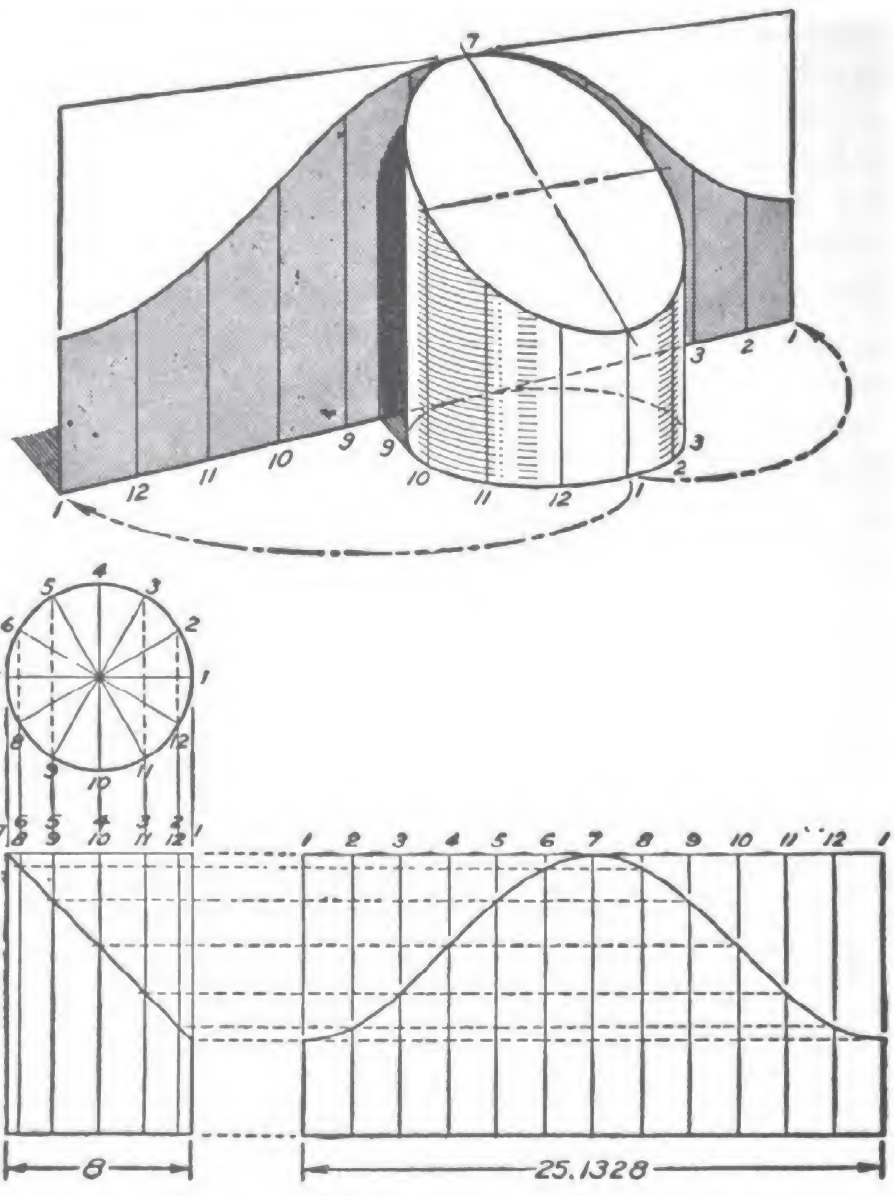


Figure 11-4.—Parallel development of a cylinder.

Such a cylinder is shown in figure 11–4. It isn't a difficult layout job when you follow directions. Those numbers are put on the layout to help you make the layout. As you develop this layout, keep careful track of those numbers by marking them on your two orthographic views and on your development.

You need a piece of paper about 24 inches by 40 inches for this job. If paper that size is not available, try making everything one-half size.

Start your layout by constructing orthographic front and top views. These views must be accurate, because the development is made from them.

Make the left outline of the front view (line *7*) 10 inches long and the right outline (line *1*) 4 inches long. The slant line connects the top ends of these two lines. Draw the 8-inch circle that forms the top view, and divide it into 12 equal parts. Number these from 1 to 12, as shown in figure 11–4.

Drop vertical lines from these 12 points so that they intersect the slant line of the front view. Some of the lines coincide so you'll have only five new ones. Number them at the top of the front view.

Start the development with the base line, which is equal to the circumference of the 8-inch circle. Erect vertical lines at each end and divide the intervening space into 12 equal spaces. Make these lines 10 inches long and label them at the top.

Now construct horizontal lines through the intersections of the front view and across the vertical lines of the development. All the points of the curve are now located. Use the points to sketch in the curved lines. You can "fair up the curve" with a french curve or ship curve.

Check the finished development, cut it out, and form it into a cylinder. The curved edge should now fit against a flat surface. The picture at the top of figure 11–4 shows how your developed pattern should look and work.

If you lay out this type of job on metal be sure to add material for making the necessary seams.

THREE-PIECE ELBOW

Not all parallel developments are as simple as the one shown in figure 11–4. You can expect more complicated shapes that will require more complicated developments.

For a two-piece, 90° cylindrical elbow you would make each half by the method shown in figure 11–4, except that the slant line would have have to be exactly 45°.

But what about a three-piece, 90° elbow, like that shown in figure 11–5? Notice that the three parts of this elbow are portions of cylinders. You'll use the same system of parallel development, but it requires some special preparation.

To start this layout, draw the view shown at the right in figure 11–5. Erect a right angle from point *A*. Measure off the height of the elbow along *AD*. Measure off the diameter of the elbow from *B* to *C*. Swing the arc *DE* with any convenient radius, with *A* as the center.

Now divide the angle *EAD* into four equal angles, with lines *FA*, *HA*, and *GA*. From points *B* and *C* draw horizontal lines to intersect radical line *GA*. Establish points *K* and *J* the same distance from *A* as are *B* and *C*. From *K* and *J* run vertical lines to intersect line *HA* at *c* and *d*. Connect points *a* and *c* and points *b* and *d* to complete the view of the elbow.

Now make developments of each of the sections. Check

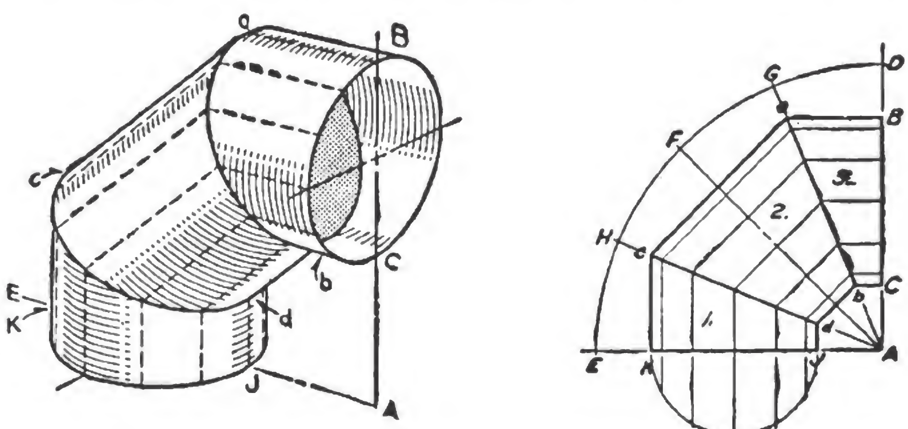


Figure 11–5.—Development of a three-piece elbow.

932348°—51——9

carefully and cut out the three sections. Put them together with transparent tape. If the three pieces fit together, form a 90° elbow, and are the desired diameter, you have made the development correctly.

RADIAL DEVELOPMENTS

The construction of a radial development is similar to that of a parallel development. In both cases the outside surface is unrolled.

Parallel development of a cylinder is like unrolling a rug; radial development of a cone is like opening up and flattening out an ice cream cone.

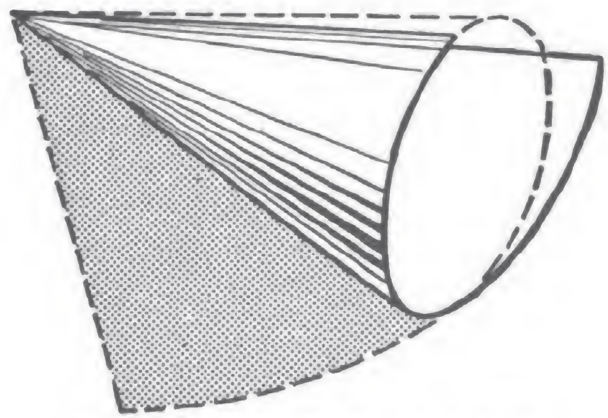


Figure 11–6.—Unrolling the cone.

You'll use evenly spaced reference lines in both cases. In one case the lines are parallel, like a picket fence. In the other case they radiate from the apex of a cone like the spokes of a wheel. The parallel development reference lines were projected horizontally. In radial development the reference lines will be transferred from the front view to the development, using the dividers.

The frustum of a cone is shown in figure 11–7. (A frustum is the part of a cone that is left when the top is sliced off.) Here's how you develop it:

Draw the front and top views. Divide the base circle (top view) into 12 equal arcs by radial lines. Project lines from these intersections vertically downward, to

intersect the line *BC* of the front view. Connect these points of intersection with lines running to the APEX, or point of the cone, at *A*.

Now mark the horizontal lines through points *a, b, c, d, e, f,* and *g*. The distances measured along *AC* from *C* are TRUE LENGTHS and are used for the development.

Start the development by swinging an arc with a radius equal to *AB* or *AC*. Use any convenient point for the center.

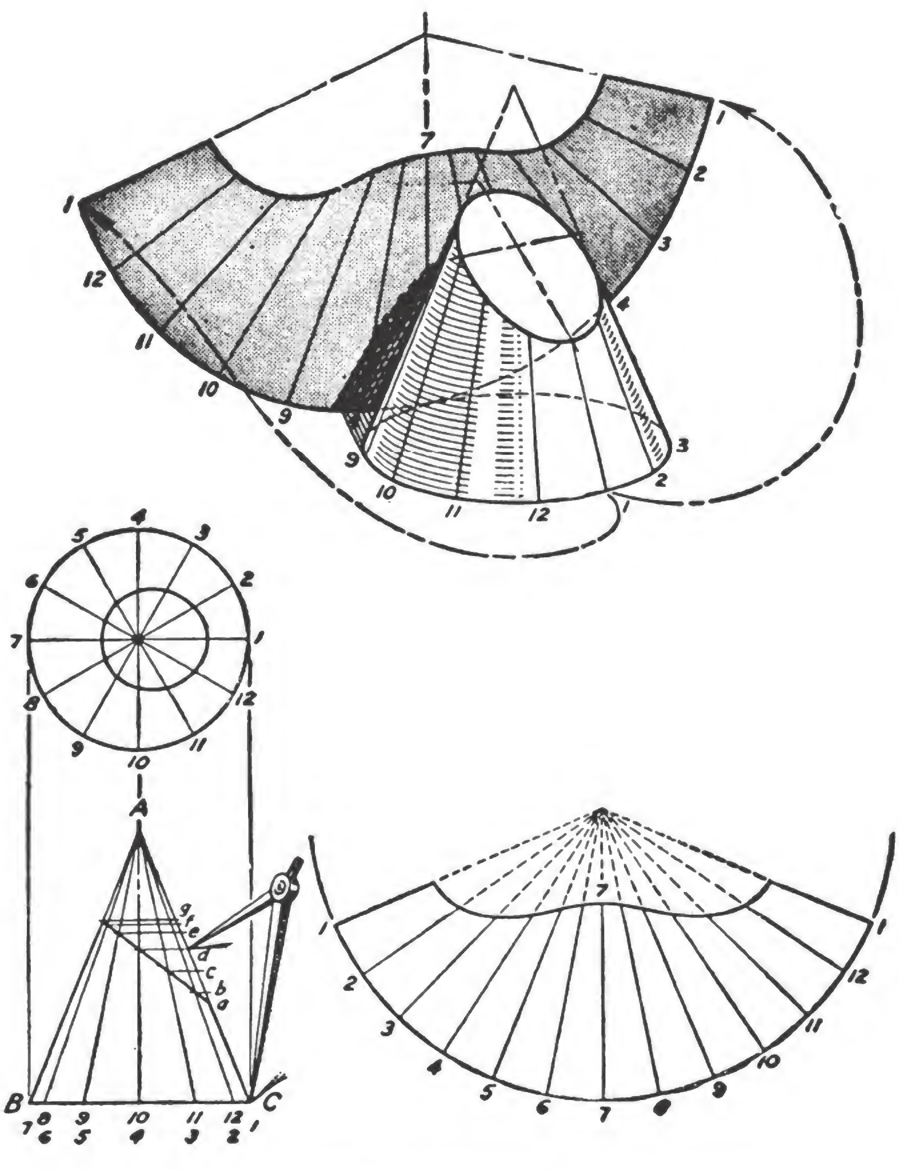


Figure 11-7.—Radial development of a cone.

Now set your dividers for one-twelfth the circumference of the circle forming the top orthographic view. Step off 12 spaces around the development arc and run lines from these points to the center of the arc. Remember that it takes 13 lines to make 12 spaces. Number the corresponding points as indicated on figure 11–7.

The next step is to mark the true lengths of the lines on the development. To get the true length of line *1*, set the dividers on *C* and *a* and transfer this distance to the development on the two lines marked *1*. In figure 11–7 the dividers are set for the true length of lines *4* and *10*. This distance is transferred to lines *4* and *10* on the development.

Complete these measurements and you have a point on each of the radial lines of the development. Fair a smooth curve through these points to complete the layout of the pattern for the cone frustum.

In making this layout don't forget to add the proper allowances for the seams.

TRANSITION PIECE

For developments of objects that cannot be made by angular development, parallel development, or radial development you'll use a method known as TRIANGULATION. It is a system for finding and using the true lengths of lines.

One problem involving triangulation is an offset funnel that has a spout that is not in the center. Another problem is a transition piece such as is required to connect a square pipe or duct to a round one. The development for one of these transition pieces is shown in figure 11–8.

Here's the procedure for making this development:

Draw a circle and a square (view I) to represent the top view of the object. The dimensions are determined by the size of the two pipes to be connected.

So that both pipes will fit properly, the transition must have four flat triangular areas which taper to a point at the corners of the square.

Divide half the circle (view I) into 8 equal arcs with your dividers, and connect the 5 points on each quarter of the circle with the corresponding corner of the square. Number the points. The lower half of the top view now shows half of the 4 triangular flat areas. As this transition is symmetrical, it is necessary to draw only one-half of the object.

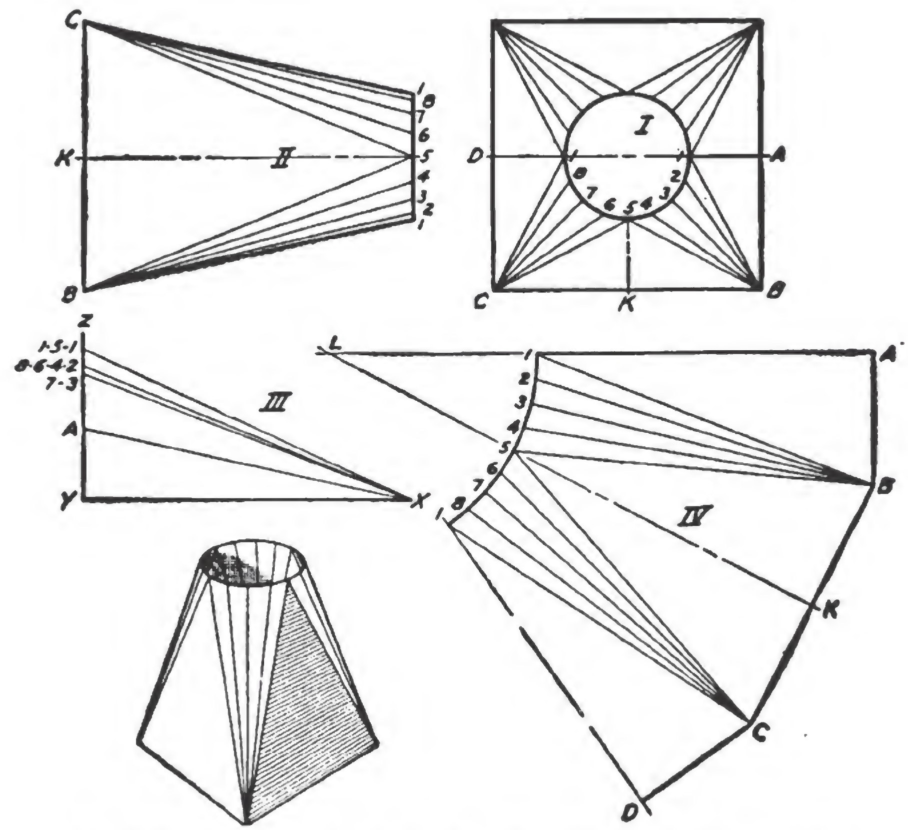


Figure 11-8.—Triangular development of a transition.

Project over to the left to construct side view II.

At some convenient location draw a horizontal line XY (view III) equal to the length of the transition piece. Erect the perpendicular YZ of an indefinite length.

The usual procedure in fabricating this transition from sheet metal would be to make the seam at *A1*, view I. This, then, is a logical place to start the development. To find the actual length of *A1*, transfer—by

means of your compass—the length of *A1* in view I to the vertical line *ZY* in view III. On this vertical line mark point *A*. Then draw line *AX*, which represents the actual length of *A1* on the transition top view, view I.

At some convenient place draw line *A1*, view IV, and mark the ends.

With your compass, measure the distance from *A* to *B* in view I, and with point *A*, view IV, as a center, swing an arc.

Find the actual length of *B1* in the same manner as you found the length of *A1*. Transfer this distance to the development, using actual *A1* as a radius and point *B*, view IV, as a center to swing an arc intersecting the short arc previously drawn with *A* as a center. Mark the intersection *B*, and draw straight line *AB*. This completes triangle *AB1*, view IV.

Set your compass to the length of chord 1-2 on the circle of view I; then, in view IV, swing an arc with point *B*, view IV, as a center, to intersect the short arc previously drawn with point *1* as a center. Mark this intersection "2" and draw straight line *B2*. This completes two sides of angle *1B2*.

Proceed in like manner to locate points, *3*, *4*, and *5*.

Line *B5* is equal in length to line *C5*, and line *BC* in view IV is equal to line *BC* in view I.

Construct the triangle *BC5* in view IV.

Locate points *6*, *7*, *8*, and *1* in the same manner that you located points *1*, *2*, *3*, *4*, and *5*.

Construct triangle *CD1*, which is similar to *AB1*.

Connect points *1*, *2*, *3*, *4*, *5*, *6*, *7*, *8*, and *1* with a smooth curve, completing half of the development. As the transition is symmetrical, use the first half of the development as a pattern to make the second half, thus completing the transition piece of the development.

If the two pipes were not on the same axis (out of line) it would be necessary to construct the entire development pattern by triangulation.

It is possible to simplify the transition development in figure 11–8 still further, as each quarter is equal. The procedure in brief is:

Construct the triangle *AB1*, view IV.

Locate points *1*, *2*, *3*, *4*, and *5*, view IV.

Construct triangle *B5K*. You know that this transition is symmetrical, so *1A* must equal *5K*, and *AB* must equal *BK*. With the actual length of *AB* as a radius and point *5*, view IV, as a center, swing an arc. Then, with the actual length of *AB* as a radius, and point *B*, view IV, as a center, swing an arc intersecting the one just drawn. Mark this intersection *K* and draw straight lines to complete triangle *B5K*. This establishes one quadrant (one-fourth of the development).

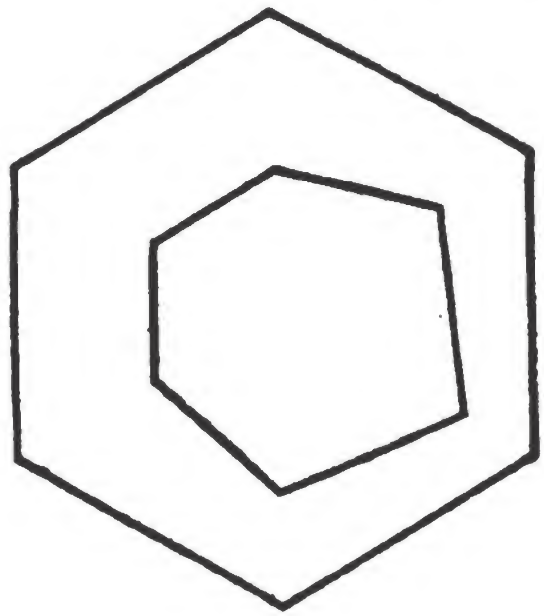
Now project lines *A1* and *K5* until they intersect at *L*, to establish the center of the development.

From center point *L*, swing a radius that cuts through points *1* to *5*.

If development *12345KBA1* is folded along line *LK*, it will form a correct development for *56781DCK5*.

QUIZ

1. Draw the front view and develop this frustum of a pyramid.

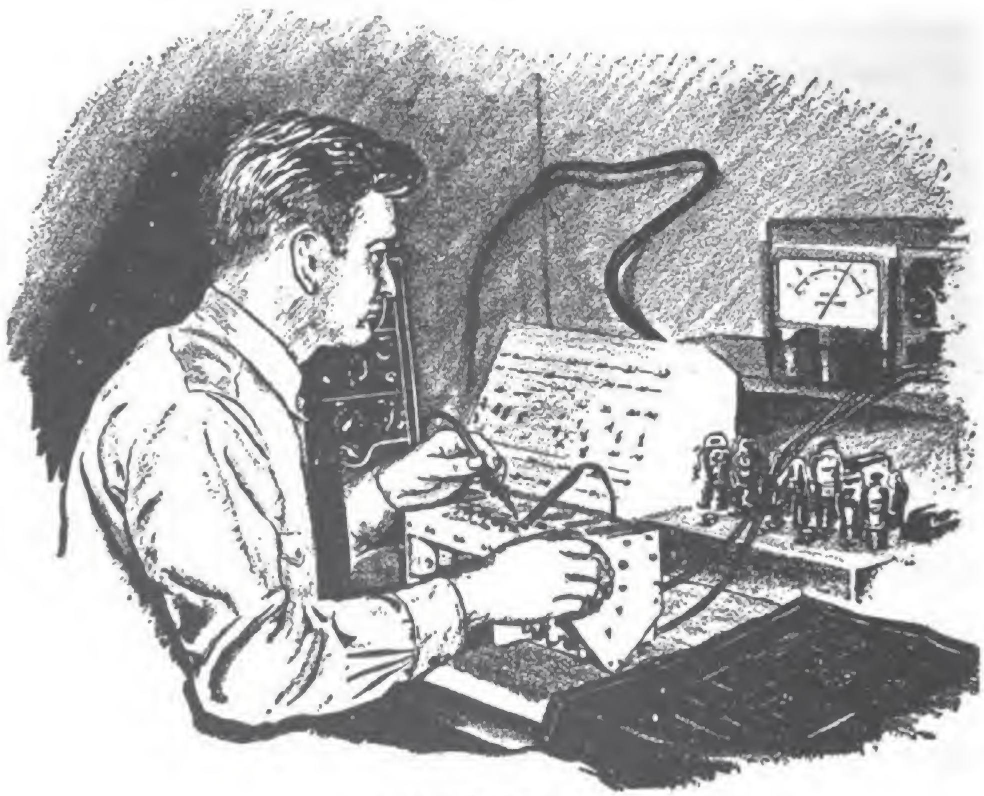


The dimensions are:	*Inches*
Diameter of circle circumscribed around the hexagon base	2
Vertical height of pyramid	2½
Highest cut (slant height)	1½
Lowest cut (slant height)	¾

2. Develop the three-piece 90° elbow shown in fig. 11–5, given these dimensions:

Vertical height of elbow cylinder	4
Diameter of cylinder	1¾

Centerpiece is twice the length of either end piece.



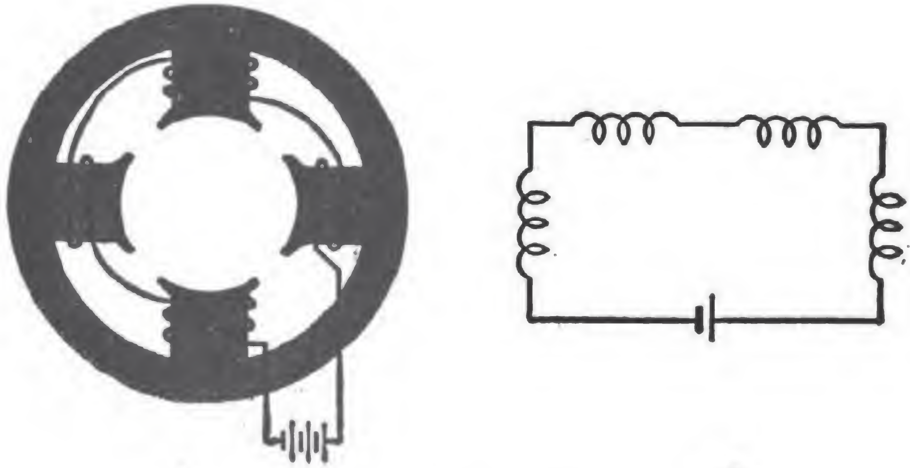
CHAPTER 12

ELECTRICAL BLUEPRINTS

DIAGRAMS AND SCHEMATICS

When a draftsman draws an electrical wiring diagram, he uses electrical abbreviations or symbols instead of drawing each piece of electrical equipment in detail. Unfortunately, an identical piece of equipment may be represented by an entirely different symbol by different draftsmen. Therefore, a single set of standard symbols is difficult to prepare; but listed here are a few of the more common ones.

Actually there are two complete lists of symbols—ELEMENTARY and SCHEMATIC. The ELEMENTARY SYMBOLS are used on wiring diagrams that show each conductor and all the connections in the circuit. These symbols are more detailed than the SCHEMATIC SYMBOLS which are used to show the location and general layout of the circuit.



A B

Figure 12-1.—Types of electrical diagrams: A—elementary; B—schematic.

Although the two diagrams in figure 12-1 look different, both show exactly the same thing—the connection pattern of coils in an electric motor. The elementary diagram (left) is somewhat like an illustration, while the schematic diagram (right) uses a form of shorthand. You'll find it easy to make and read schematics when you know the symbols and their meanings and uses.

ELEMENTARY WIRING DRAWINGS

All shipboard wiring blueprints are classified under three general headings: ELEMENTARY wiring drawings, ISOMETRIC wiring drawings, and wiring DECK PLANS.

The elementary wiring drawing is, as the name implies, as simple and detailed as possible. It shows each individual conductor in the circuit and every connection made. It may or may not show the connection boxes themselves. In all interior communication (IC) circuits the lugs in each connection box are stamped with the proper lead markings. The elementary wiring diagram shows these lead markings alongside each lead of the circuit.

An elementary wiring drawing for a controller usually shows the relative position of the various components

of the controller. Most elementaries, however, show nothing of the fixtures or cable runs, and for this reason they are not drawn to scale. Elementary drawings use the elementary type of symbols. An elementary drawing would be used to check proper connection in a circuit or to make the initial hook-up. Each elementary wiring blueprint contains one circuit only.

ISOMETRIC WIRING DRAWINGS

Each electrical system has its own isometric wiring drawing. If the individual system is not too large, it will be covered by one blueprint. There will be a separate isometric wiring diagram for each IC circuit.

In isometric drawings the decks are arranged in tiers, starting at the bottom with the hold and successively arranged to show the bridges and superstructure. Section and divisional bulkheads are shown, as well as the bulkheads that divide the deck into the main compartments. The centerline is marked with frame numbers every 5 or 10 frames. The outer edge of each deck is drawn with the general outline of the shape of the ship.

All athwartship lines are shown at an angle of 60° to the centerline, and the location of compartments as shown by the blueprint gives an accurate idea of the deck arrangement, although not in detail. The purpose of distorting the athwartship lines is to permit the continuous representation of cables passing between decks. Cables running from one deck to another are drawn as light lines at right angles to the centerline.

The exact location of fixtures and cable runs cannot be satisfactorily arrived at by use of an isometric wiring blueprint, because the locations shown are only approximate. The symbol numbers of the fixtures in the circuit are given and also the cable numbers and sizes. This aids the electrician in associating each circuit with its elementary wiring drawing. An isometric wiring diagram for a turret is shown in figure 12–2. What this diagram means is illustrated in figure 12–3.

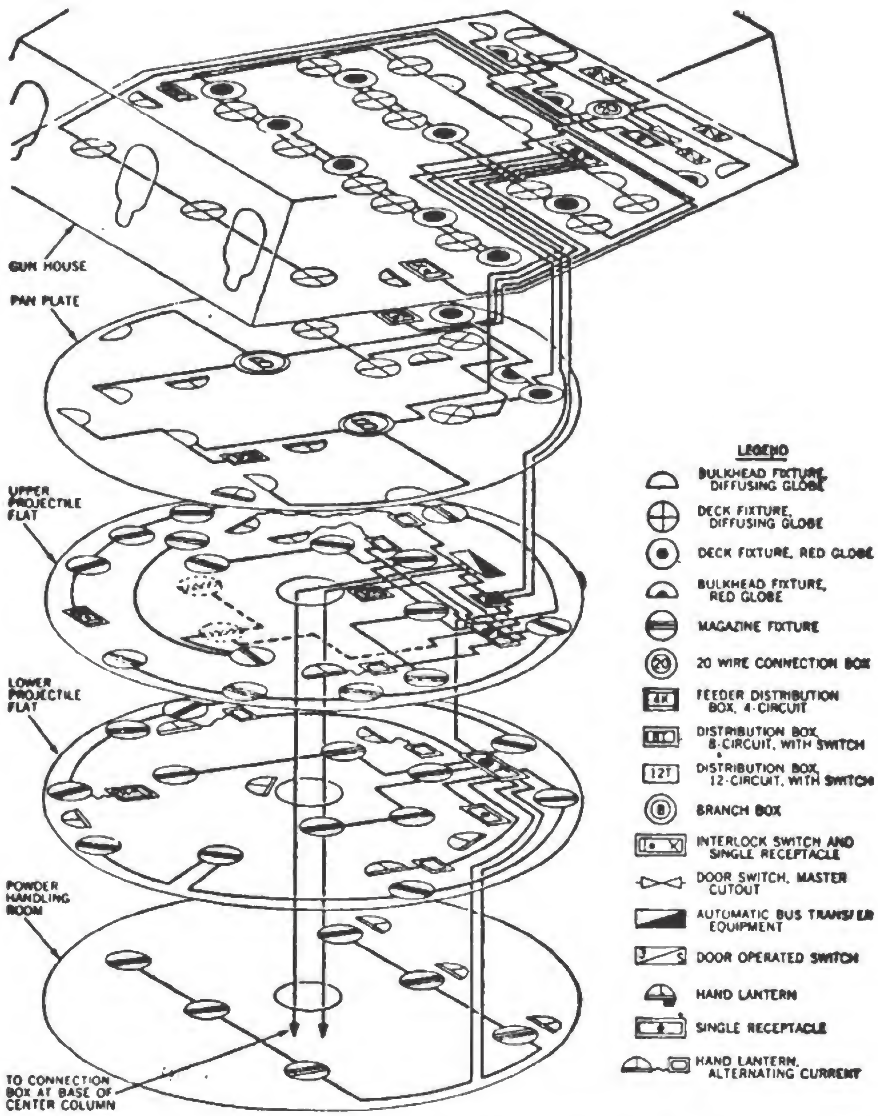


Figure 12-2.—Isometric wiring diagram for 8-inch turret illumination system.

Elementary and isometric presentations of a circuit often are on the same blueprint. Isometric wiring drawings use schematic symbols and are never drawn to any one set scale.

A cable, regardless of the number of conductors, is represented on an isometric wiring diagram by a single line, and no attempt is made to show the proper connections in connection boxes or at fixtures. An isometric type of drawing thus shows at a glance a rough picture

of the entire circuit's layout. Isometric wiring diagrams of lighting and power circuits usually are used to indicate only the main supply cables, feeders, and their associated equipment.

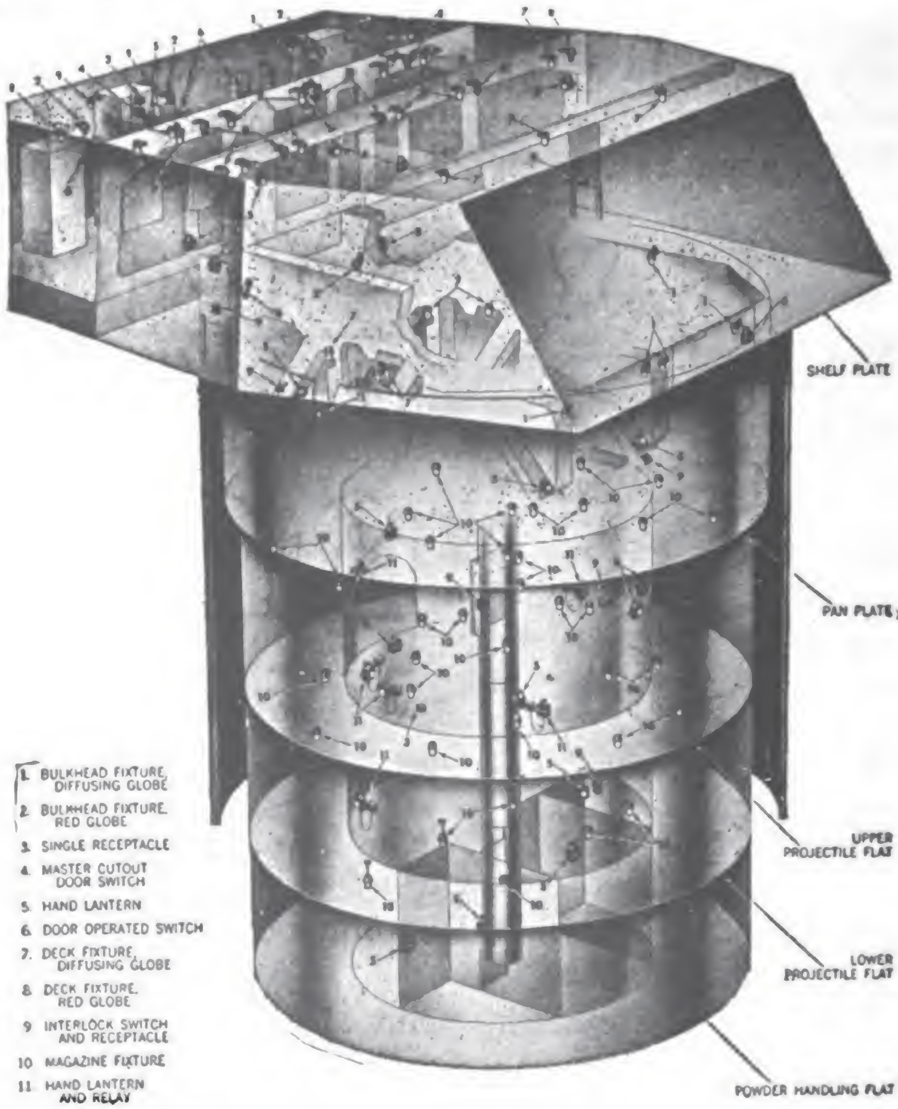


Figure 12–3.—The turret illumination system indicated by the wiring diagram in figure 12–2.

WIRING DECK PLANS

The wiring deck plan is a blueprint used chiefly in construction. It enables the electrician at a naval shipyard to lay out his work for a number of cables without

referring to each individual isometric wiring drawing. Wiring deck plans do not distort the athwartship members; they represent a true plan.

WIRING CONNECTIONS

In the schematic diagram shown in figure 12–4 notice the two methods of representing wire connections for the three-lamp and battery circuit.

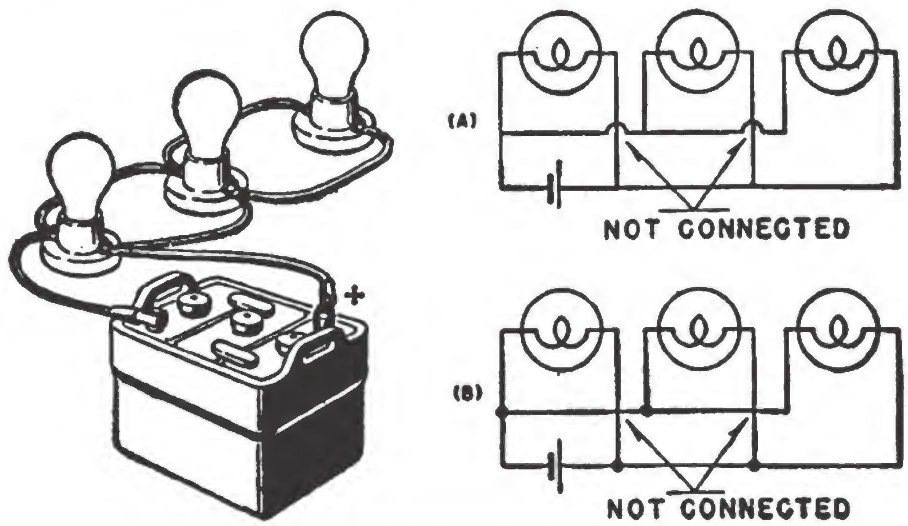


Figure 12–4.—Wiring connections.

By the method shown in *A* a half circle or loop is used to show a crossing of two wires that are not connected. A connection is shown by two lines crossing or intersecting at right angles.

By method *B* a crossing point of two wires is a connection only if you place a dot there.

PRACTICE DIAGRAMS

Figure 12–6 is a schematic diagram of a headset sound-powered phone and figure 12–5 is a wiring diagram for a four-cylinder V-type powerboat engine. Study these diagrams and then see if you can trace similar ones for some electrical equipment with which you are familiar. Check your drawings and labels against the symbols shown at the end of this chapter.

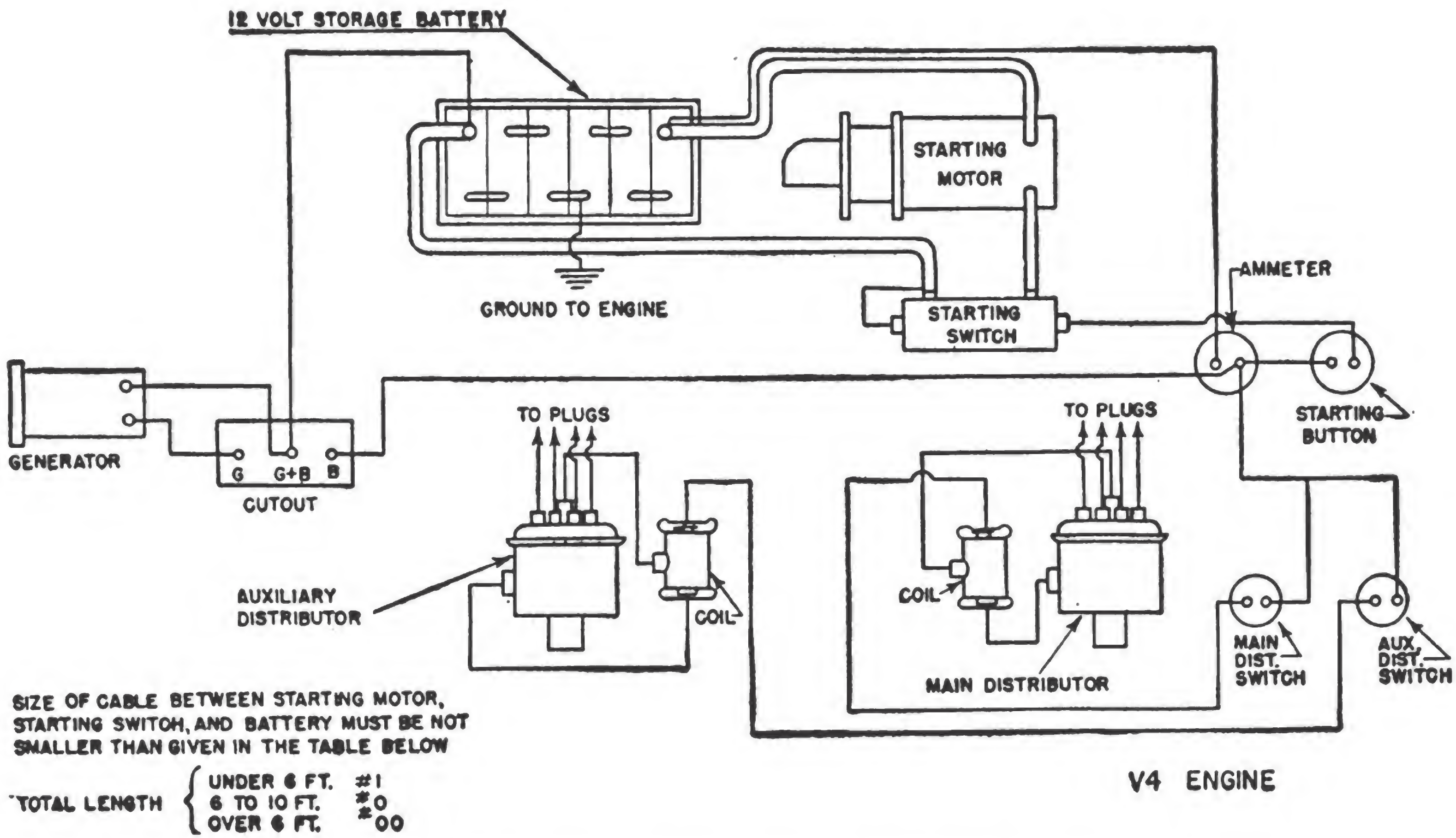


Figure 12-5.—Wiring diagram for V4 powerboat engine.

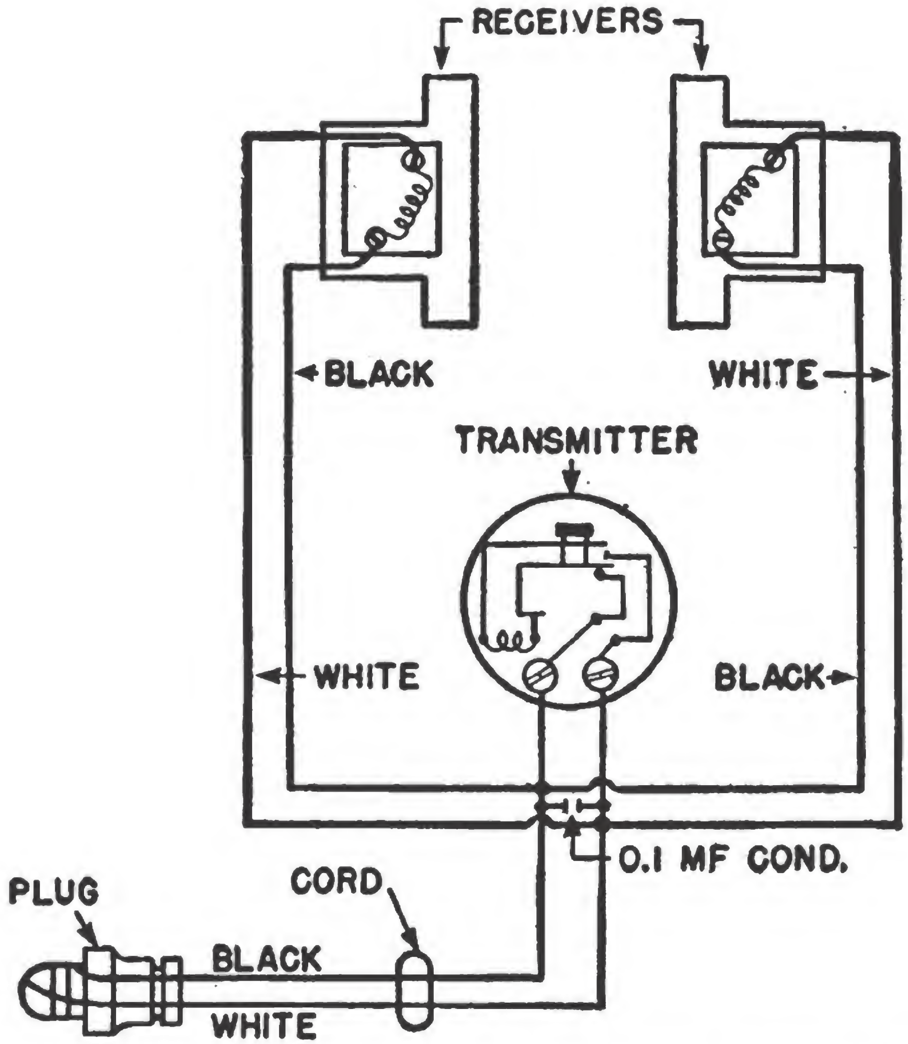


Figure 12-6.—Schematic diagram of sound-powered telephone.

ELECTRICAL AND ELECTRONIC SYMBOLS

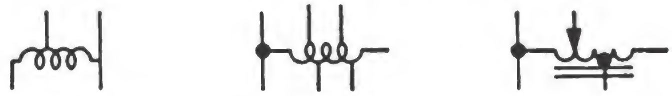
A schematic diagram does not tell how the parts look nor how they are constructed. Its purpose is to show how the parts are connected for the OPERATION of the electrical circuit. Once you have learned the basic symbols, you will find electrical blueprints easy to read. Get acquainted with these basic symbols and you will be able to take the variations in your stride. It is a good idea to refer to specifications and standards at regular intervals, because these standards do change from time to time.

ELECTRICAL and ELECTRONIC SYMBOLS for USE on DRAWINGS
JAN-STD-15

ANTENNA

AERIAL COUNTERPOISE DIPOLE LOOP

AUTOTRANSFORMER

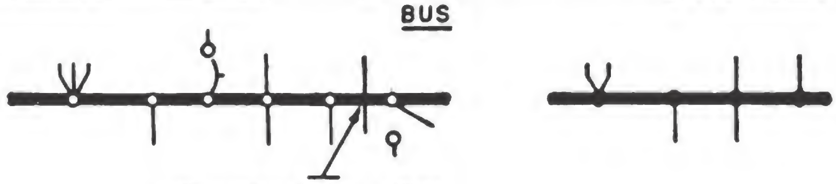


SINGLE-PHASE FIXED TAPS VARIABLE

BATTERY

CELL POLARITY SHOWN VOLTAGE SHOWN COUNTER EMF

BUS



NO CONNECTION HERE

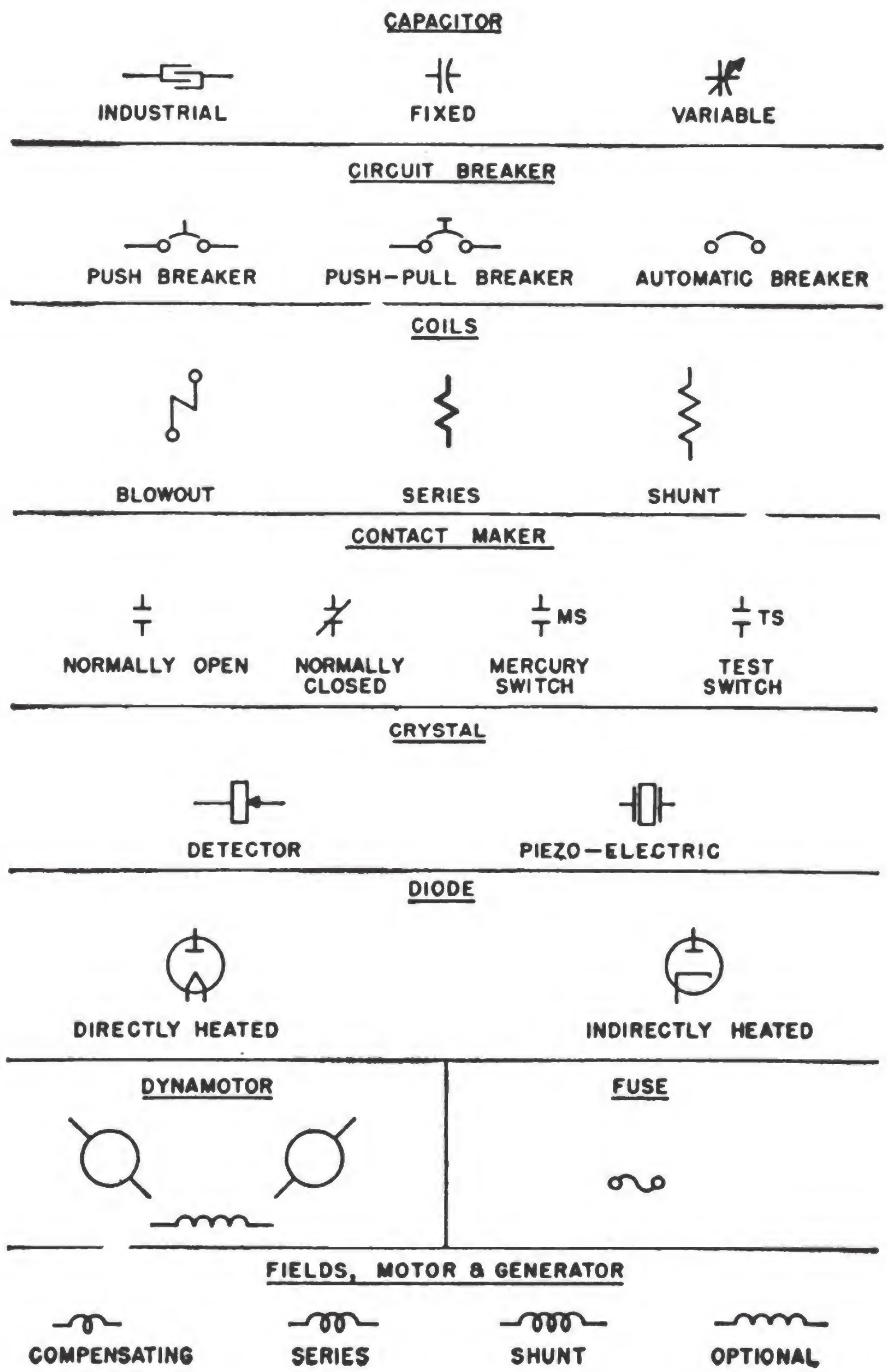
CONDUCTORS

NO CONNECTION JUNCTION NO CONNECTION JUNCTION

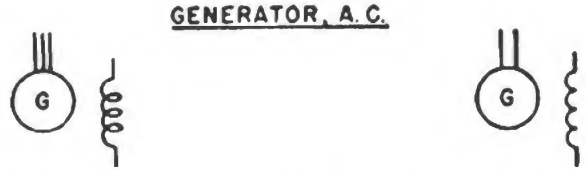
INCOMING CURRENT OUTGOING CURRENT

SINGLE COAXIAL COAXIAL, DOUBLE SHIELDED

932348°—51——10


CAPACITOR
INDUSTRIAL
FIXED
VARIABLE
CIRCUIT BREAKER
PUSH BREAKER
PUSH-PULL BREAKER
AUTOMATIC BREAKER
COILS
BLOWOUT
SERIES
SHUNT
CONTACT MAKER
MS
TS
NORMALLY OPEN
NORMALLY CLOSED
MERCURY SWITCH
TEST SWITCH
CRYSTAL
DETECTOR
PIEZO-ELECTRIC
DIODE
DIRECTLY HEATED
INDIRECTLY HEATED
DYNAMOTOR
FUSE
FIELDS, MOTOR & GENERATOR
COMPENSATING
SERIES
SHUNT
OPTIONAL

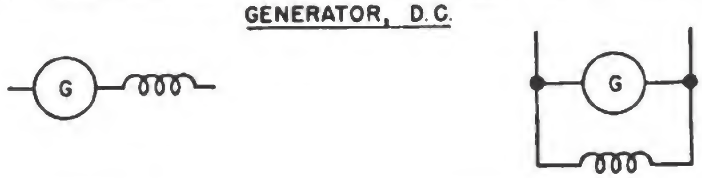
GENERATOR, A.C.



THREE-PHASE SYNCHRONOUS GENERATOR

SINGLE-PHASE SYNCHRONOUS GENERATOR

GENERATOR, D.C.



SERIES

SHUNT

GROUND

INDICATING LIGHT

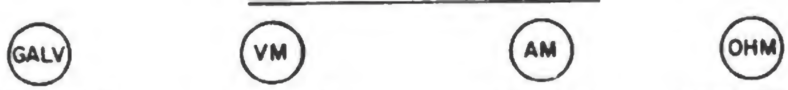
GAS FILLED

INDUCTOR

VARIABLE

MAGNETIC CORE

INSTRUMENTS AND METERS



GALVANOMETER

VOLTMETER

AMMETER

OHMMETER

WATTMETER

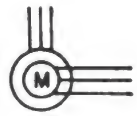
SYNCHROSCOPE

LAMP

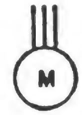
BALLAST

ILLUMINATING

MOTORS, A.C.

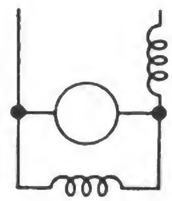


THREE-PHASE INDUCTION MOTOR

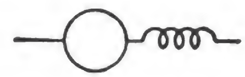


THREE-PHASE SQUIRREL CAGE MOTOR

MOTORS, D.C.

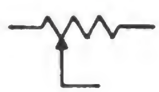


COMPOUND MOTOR

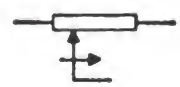


SERIES MOTOR

POTENTIOMETER



DETAILED



SIMPLE

PUSHBUTTON SWITCH

NORMALLY OPEN

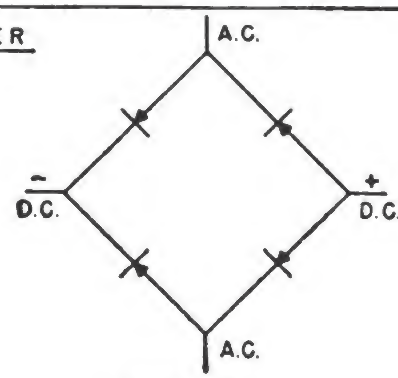
NORMALLY CLOSED

SPRING RETURN

NON-SPRING RETURN

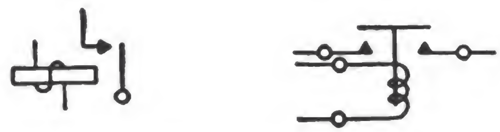
RECTIFIER

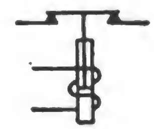
HALFWAVE



FULL WAVE

RELAY





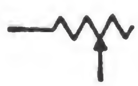
MAKE CONTACTS BREAK CONTACTS

RESISTOR

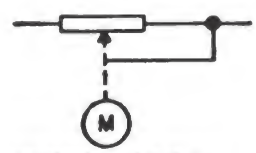
SIMPLE

DETAILED

RHEOSTAT



DETAILED

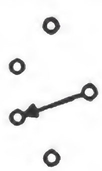


MOTOR DRIVEN

SOLENOID

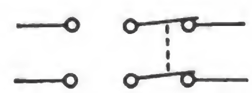
PLUNGER TYPE

SWITCH



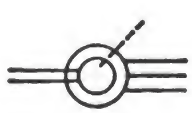
ROTARY

TOGGLE SWITCH
SPST

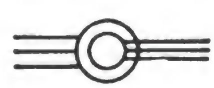


TOGGLE SWITCH
DPDT

SYNCHROS

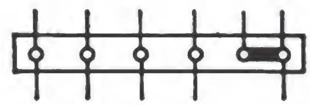


TRANSMITTER-
RECEIVER



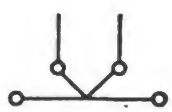
DIFFERENTIAL
TRANSMITTER

TERMINALS

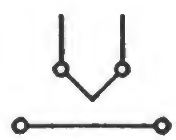


TERMINAL STRIP

THERMOCOUPLE



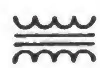
DIRECTLY HEATED



INDIRECTLY HEATED

TRANSFORMERS

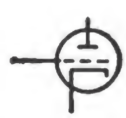
AIR CORE



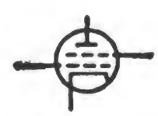
MAGNETIC CORE

POWDERED IRON CORE

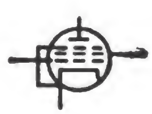
TUBES, ELECTRON



TRIODE



TETRODE



PENTODE

COLD CATHODE

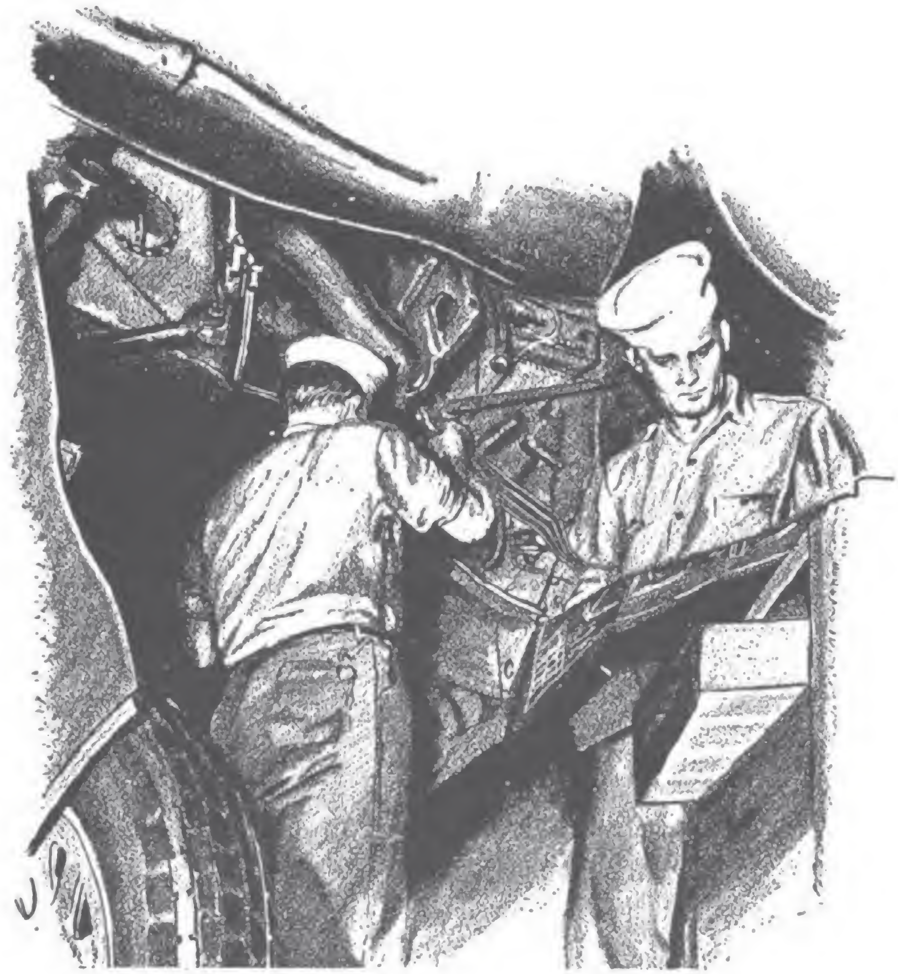
E = VOLTAGE	v = VOLTS
I = CURRENT	a = AMPERES
R = RESISTANCE	Ω = OHMS
f = FREQUENCY	~ = CYCLES PER SEC.
+ = POSITIVE	− = NEGATIVE

GENERAL SYMBOLS

A piece of equipment without a standard symbol is represented by a rectangle, circle, or combination of both. Circles indicate rotating equipment; rectangles are used for nonrotating equipment. The equipment is identified by a number or label inside or outside the rectangle or circle. A watertight unit is usually shown by simply doubling the outer lines of the symbol.

QUIZ

1. What are the two types of electrical diagrams?
2. a. Are isometric wiring diagrams drawn to one set scale?
   b. Do isometric wiring diagrams use elementary or schematic symbols?
3. What is the chief use of wiring deck plan?
4. What are two methods of showing wires that cross without interconnection?
5. In schematic electrical symbols what is generally done to show water-tightness?



CHAPTER 13

MECHANICAL AND PIPING SYMBOLS

MECHANICAL SCHEMATIC DIAGRAMS

Figure 13–1 shows a schematic diagram of a simple mechanism connected to a ship's speed indicator. Note the symbols in the legend and how they are used on the diagram. Notice that the gears are described by *P* and *T*. *P* is the pitch or number of gear teeth per inch; *T* is the number of teeth on that particular gear. See if you can trace the mechanism through from the crank to the dial.

Fire Controlmen, Gunner's Mates, and Torpedomen often have to read mechanical schematics like that shown

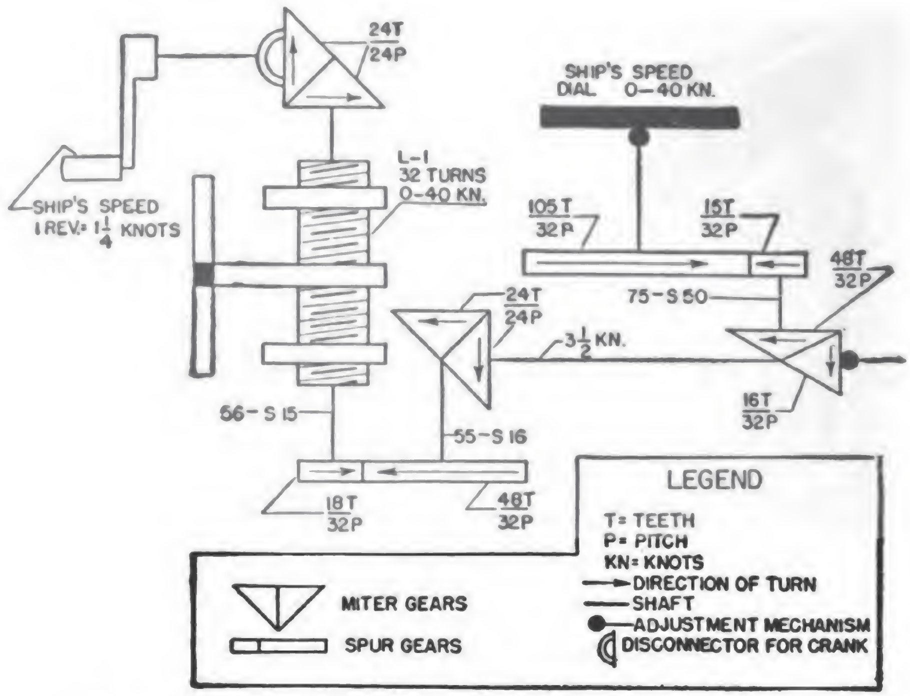


Figure 13–1.—Schematic diagram of a mechanism.

in figure 13–2. The purpose of this type of diagram is to show how certain standard mechanical units are hooked up together. These standard units are represented by special symbols, and the man who uses the drawing is expected to have previous knowledge as to how the unit works.

For example, the sliding device, shown at the lower left in figure 13–2, is a MULTIPLIER. It is a mechanical linkage with three shafts coming out of it. Two are drive shafts, usually called INPUTS; one is a driven shaft, or OUTPUT. If one of the drive shafts turns 10 times and the other drive shaft turns 2 times, the driven shaft will turn 10 × 2, or 20 times.

Each little circle with an × inside it represents a DIFFERENTIAL GEAR. These gear assemblies are so arranged that if two gears are turned, the third will move as much as the combined movement of the other two.

Other devices pictured with symbols are the two integrators in the upper corners, two component solvers, a computing cam, dials, and hand cranks.

The lines joining the symbols are the important part of the diagram. Each line indicates the existence of a mechanical connection. It does not identify the connection—it may be a single gear or it may be a complicated arrangement of many gears and shafts. The lines do not ordinarily represent the actual position of shafting. Instead, they are drawn in any convenient location, like the lines of an electrical wiring diagram.

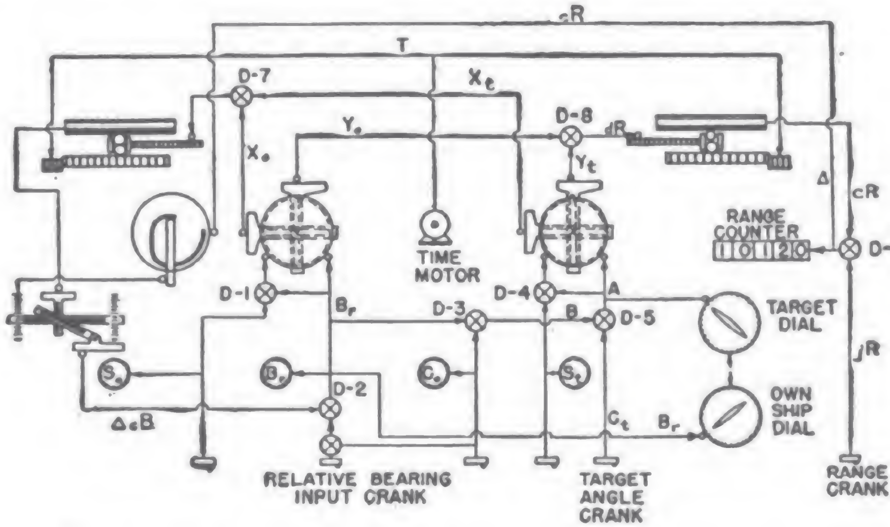


Figure 13–2.—Mechanical schematic of a rangekeeper.

The mechanism illustrated, a simple rangekeeper, is a computing device used in fire control. If proper values of your own ship's speed and course, target ship's speed and course, and initial range and bearing of the target are cranked into the rangekeeper, the range-counter dial will continue to show the correct range between the moving ships as long as the time motor continues to run.

PIPING SYSTEMS

If you played basketball or football in school, you used schematic diagrams. The coach drew the diagrams. He showed the location of the players' positions by small circles and their movements by lines and arrows. The draftsman uses similar diagrams to show the ship's fresh

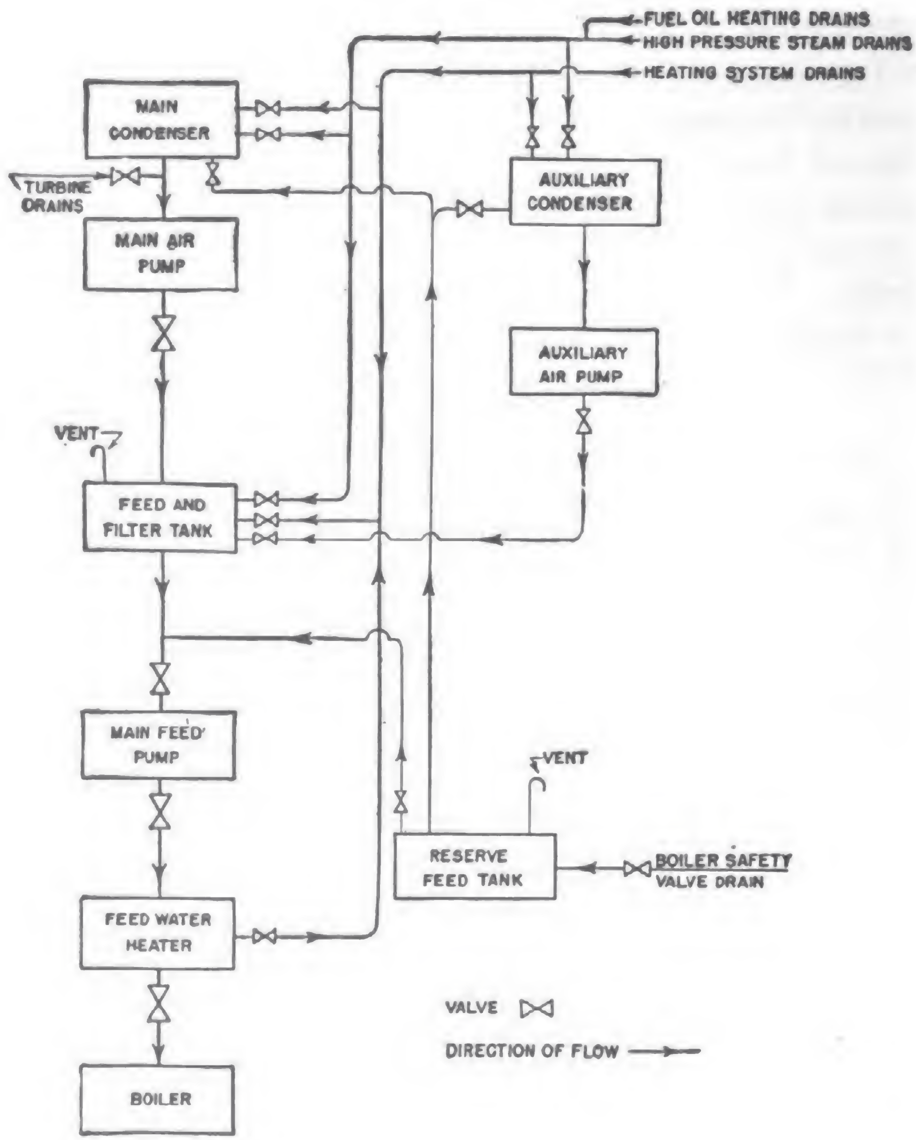


Figure 13-3.—Open feedwater system for boilers.

water system, lubrication systems, fuel oil systems, refrigeration system, and drainage systems.

The secret of using these schematic diagrams is knowing and recognizing the symbols. Most of these symbols are standardized. If any unusual symbols are found on the diagram, you'll find an explanation in the legend, which is an explanatory reference table or block.

STUDY DIAGRAMS

Study the diagrams, figures 13–3, 13–4, 13–5, and 13–6. Don't be disappointed if the lines in the diagram don't look exactly like pipes. If they did, it would be a mechanical drawing and not a diagram. The diagram will clearly indicate the locations of valves, vents, gages, tanks, pumps, etc. It will show the direction of flow of the liquid or steam in the pipes and tell what kind of substance it is.

Immediately following these diagrams is a table containing some of the more common symbols used in diagrams of military equipment. Refer to them while studying the diagrams.

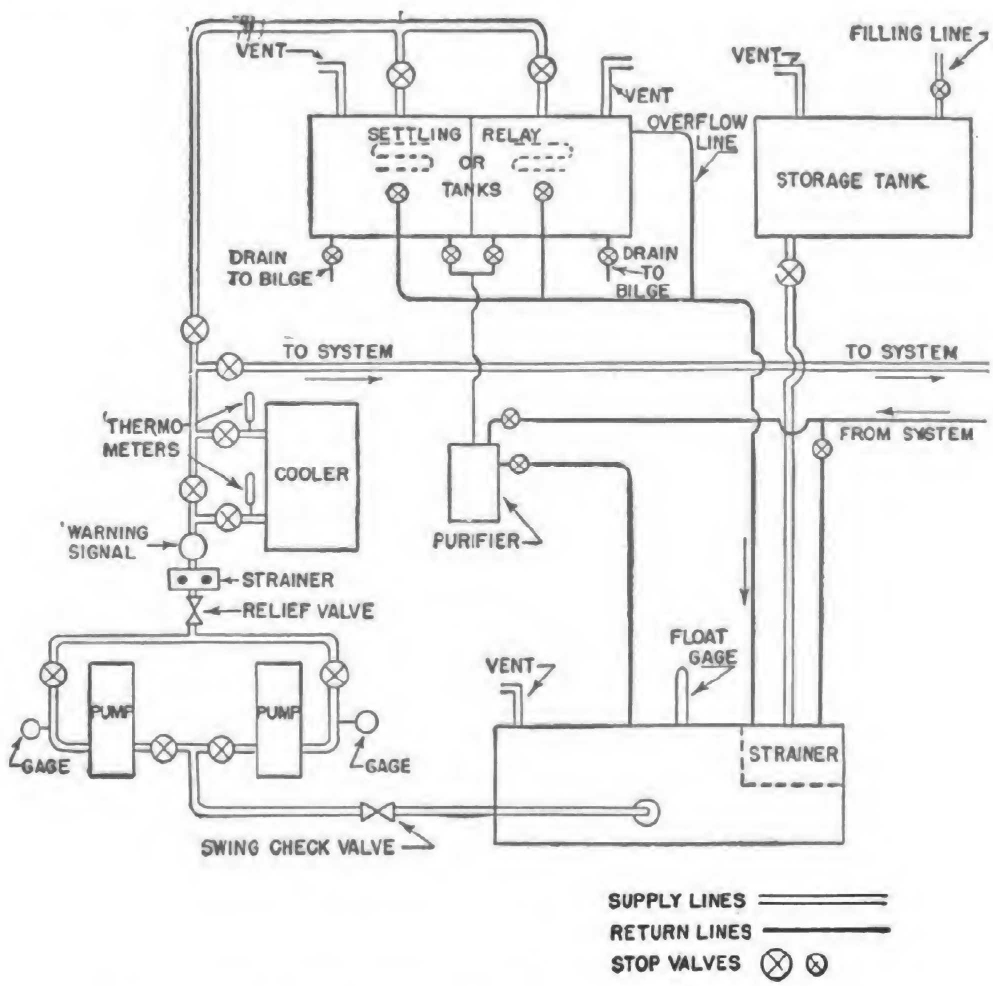
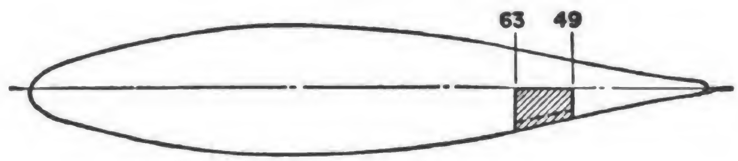


Figure 13–4.—Typical forced lubrication system found on naval vessels.



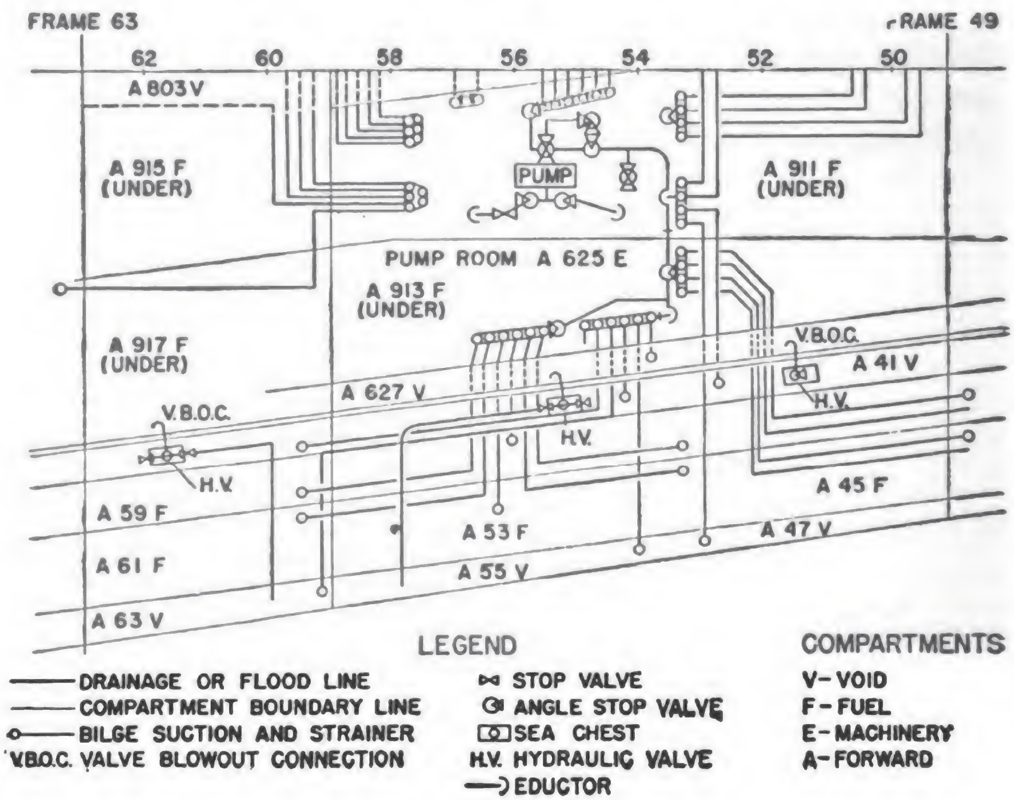


Figure 13–5.—Detailed sketch of drainage and flooding system. NORTH CAROLINA class battleships.

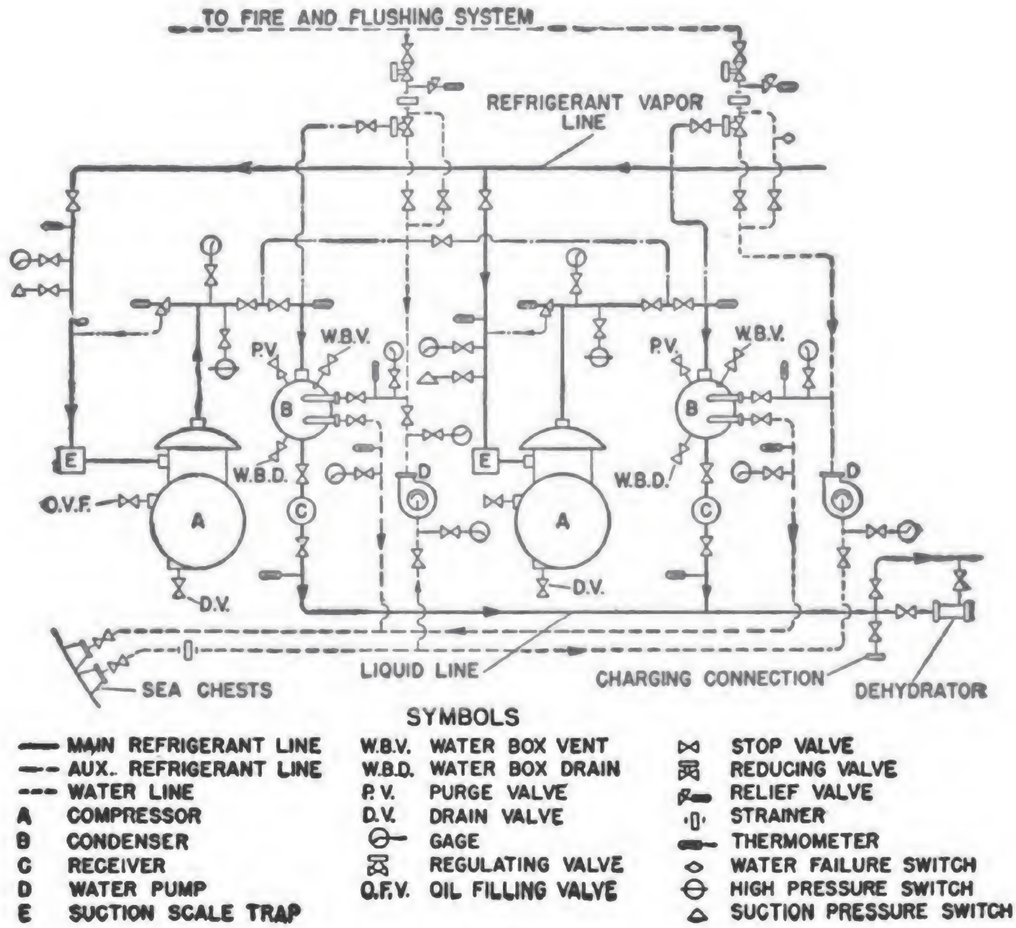


Figure 13–6.—Diagram of ship refrigeration system.

PIPING SYMBOLS

1. Designation of relative importance of piping systems

Principal system

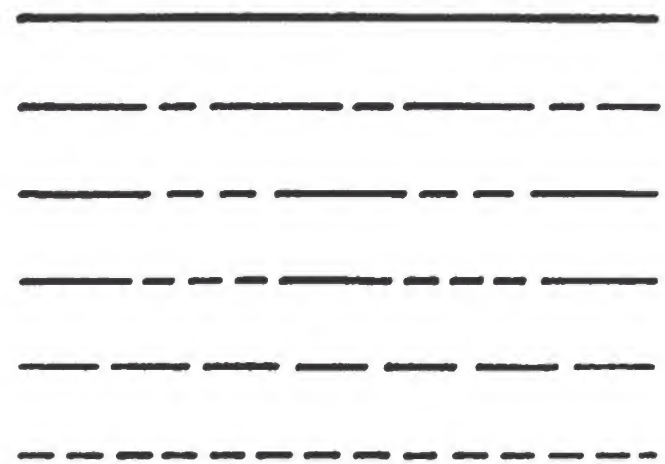
Second system in importance

Third system in importance

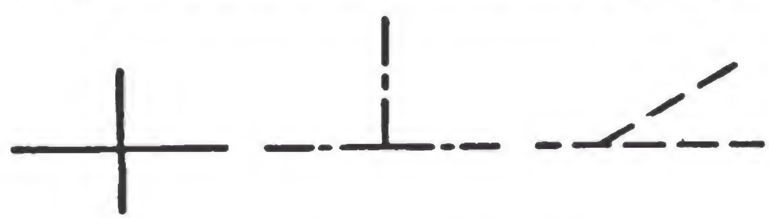
Fourth system in importance

Fifth system in importance

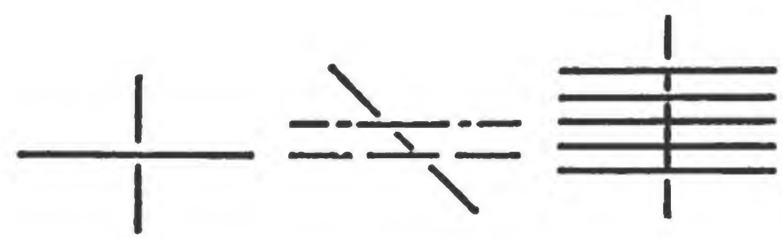
Invisible lines (adequately labeled as to system)



2. Typical intersections and crossovers of piping lines



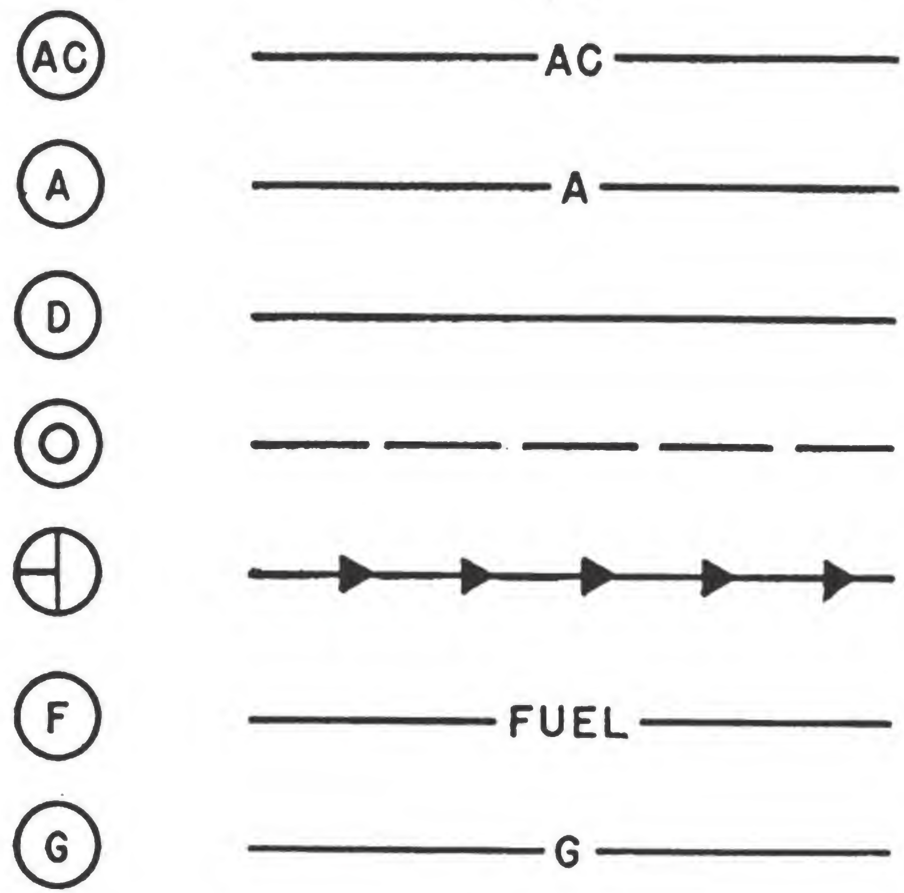
Typical intersections



Typical cross-overs

3. Detail labeling of piping lines on drawings

Service	*Riser or stack*	*Symbol*
Acetylene		
Air, compressed		
Drain, building*		
Drain, storm or roof		
Drain, subsoil		
Fuel supply (except gasoline)		
Gas		



*Above or below grade.

932348°—51——11

Gasoline

Hydrogen

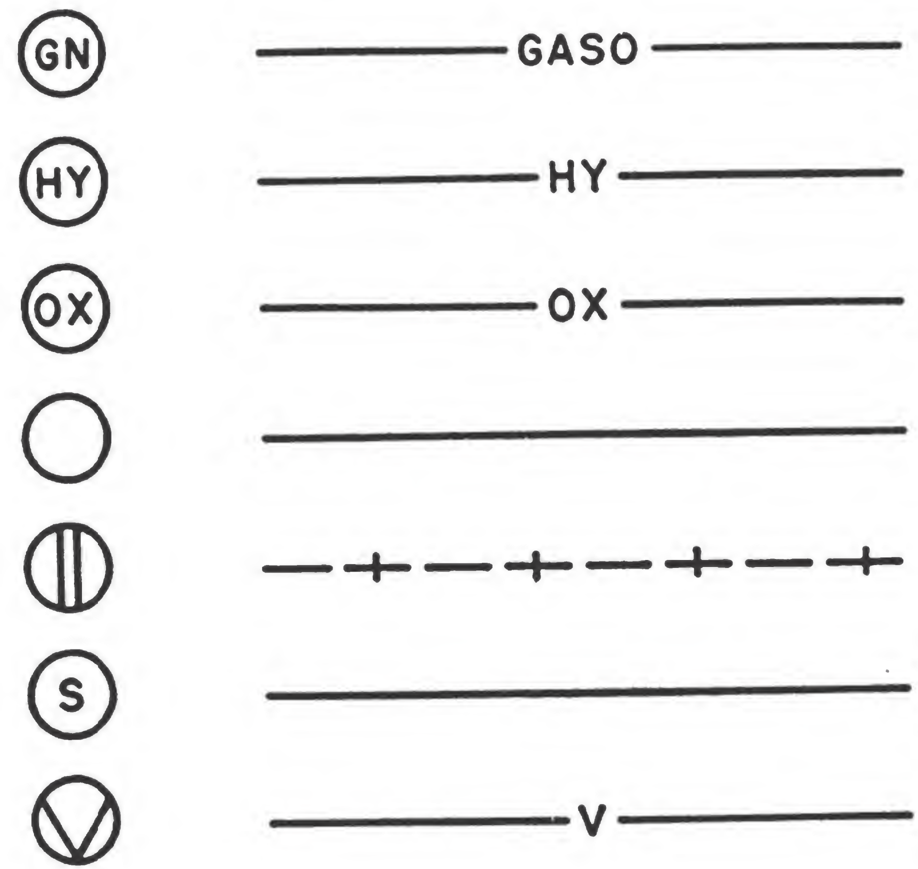
Oxygen

Sewer, sanitary*

Sewerage, combined

Soil*

Vacuum



*Above or below grade.

Vent

Vent, acid

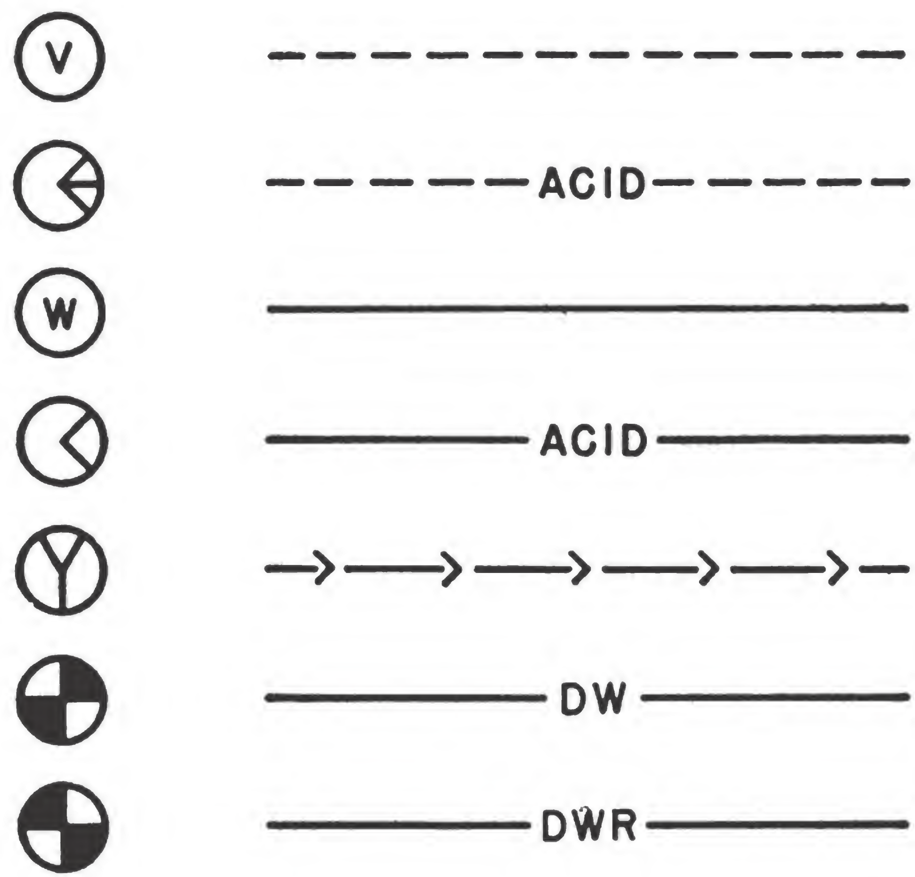
Waste *

Waste, acid or chemical

Waste, indirect

Water, chilled drinking

Water, chilled drinking return



*Above or below grade.

Water, cold

Water, fresh

Water, hot

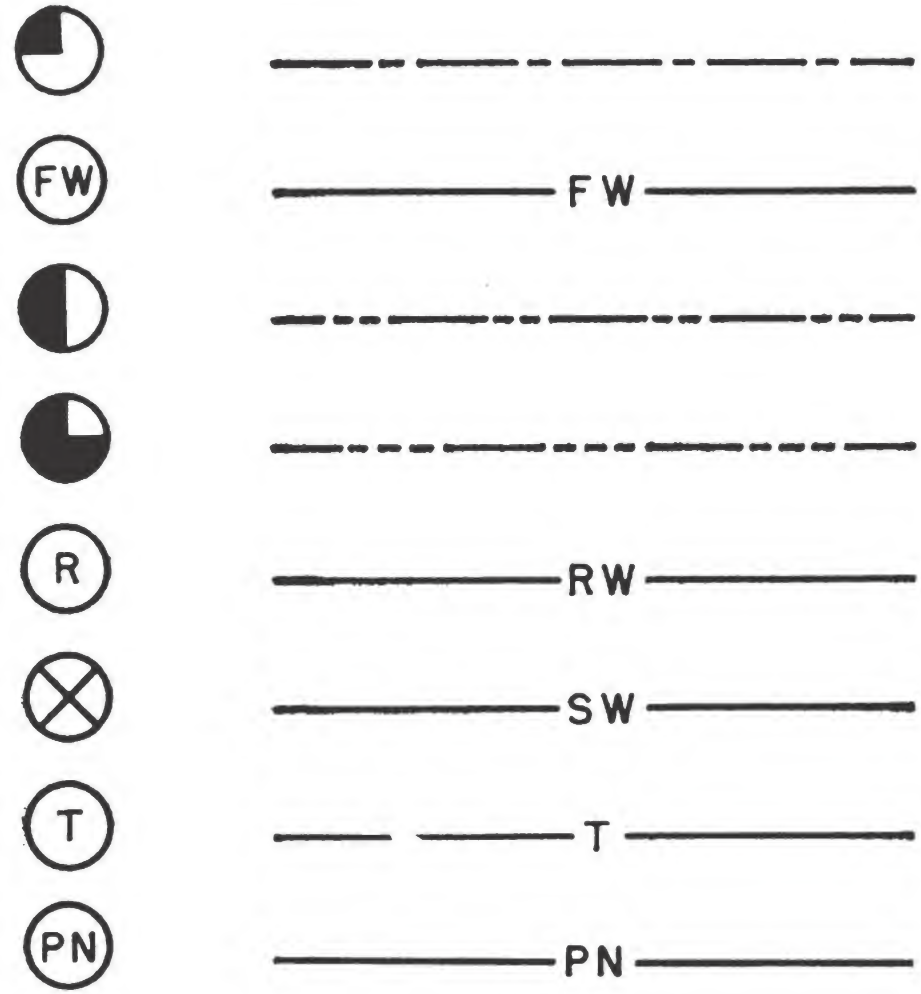
Water, hot return

Water, raw

Water, salt

Water, tempered

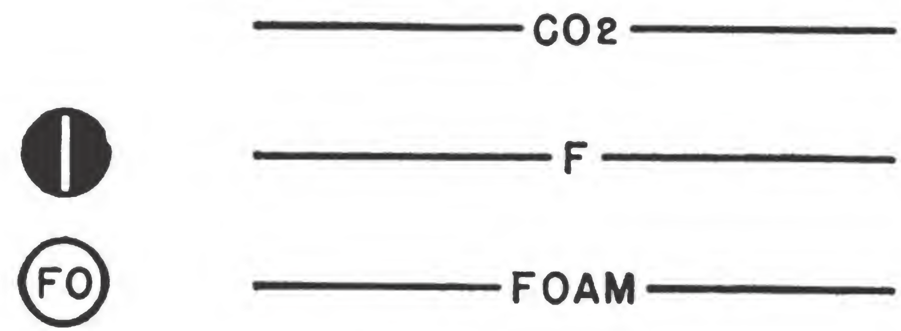
Tube runs, pneumatic



Carbon dioxide system

Fire line

Foam solution

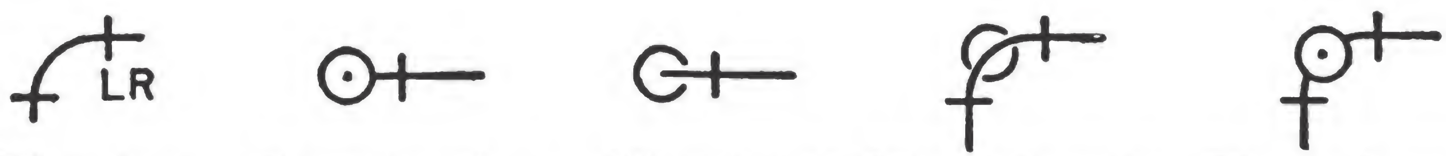


4. Common piping symbols

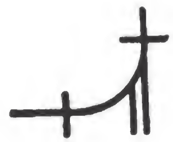
JOINTS

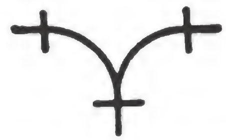
Flanged ends | Screwed ends | Bell-and-spigot ends | Welded and brazed ends | Soldered ends

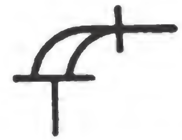
ELBOWS

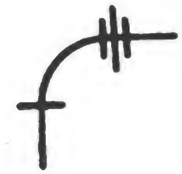


Elbow, long radius | Elbow, turned up | Elbow, turned down | Elbow, side outlet, outlet down | Elbow, side outlet, outlet up

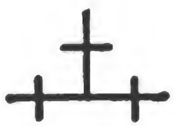

Elbow, base


Elbow, double branch, or plain double T–Y


Elbow, reducing

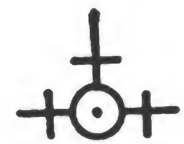

Elbow, union

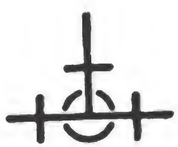
TEES

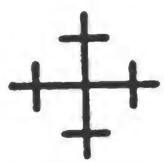

Tee

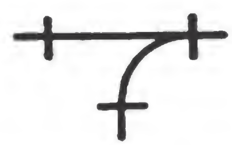

Tee, outlet up

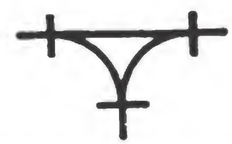

Tee, outlet down


Tee, side outlet, outlet up

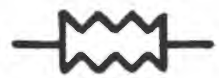

Tee, side outlet, outlet down


Cross


Tee, single sweep, or plain T–Y


Tee, double sweep

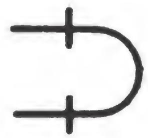
EXPANSION JOINTS



Expansion joint, bellows

Expansion joint, sliding

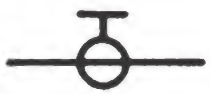
BEND AND SLEEVE



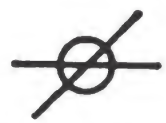
Return bend

Sleeve

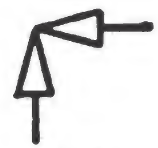
VALVES



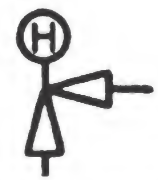
General symbol



General symbol, check



Angle

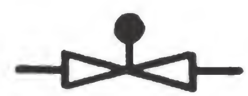


Angle, hydraulically operated

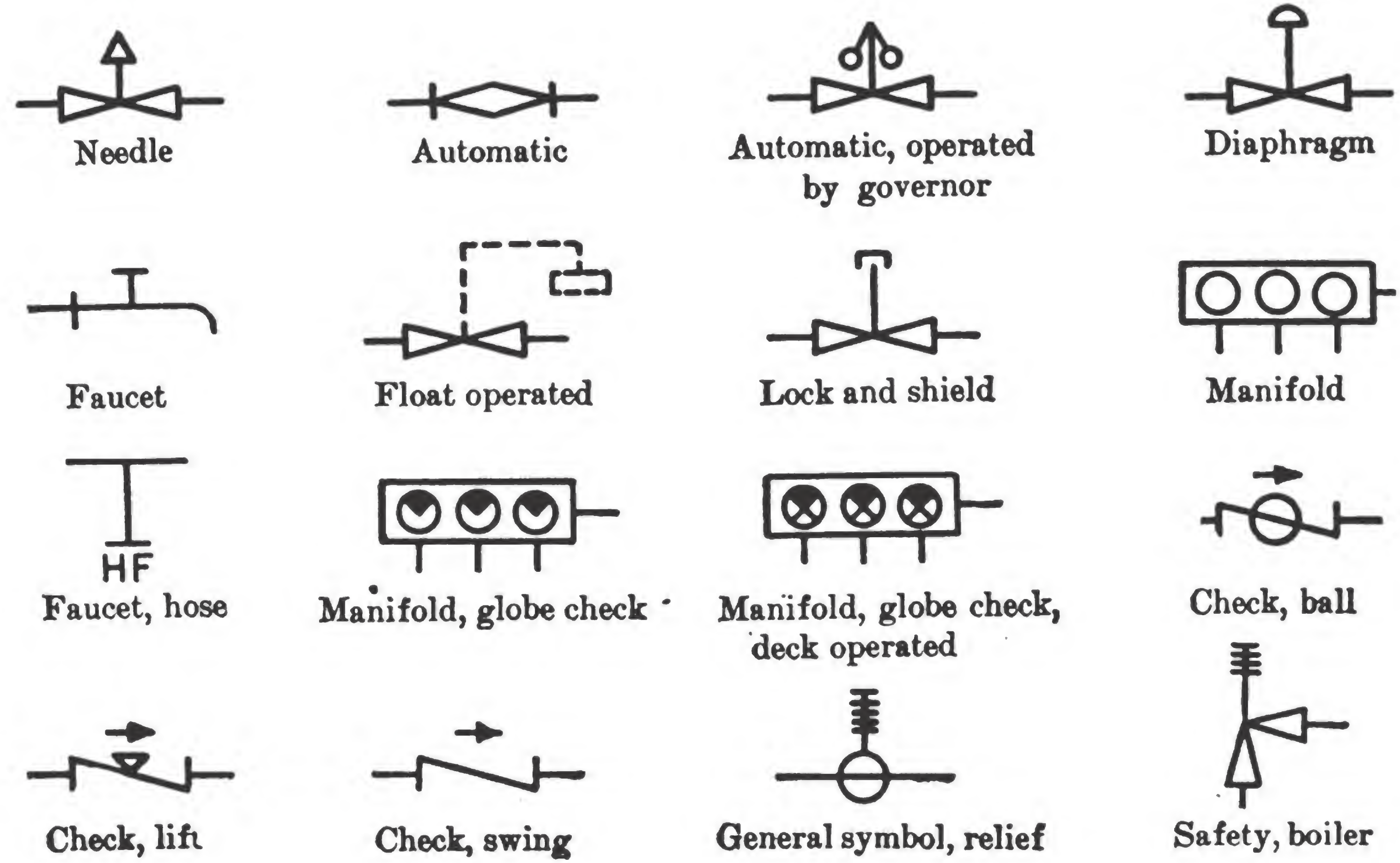
Cross

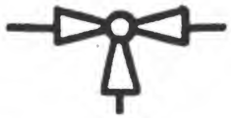
Gate

Globe

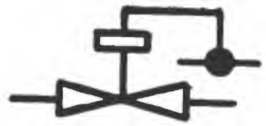


Globe, locked closed

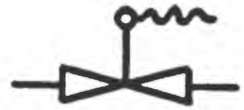

Needle
Automatic
Automatic, operated by governor
Diaphragm
Faucet
Float operated
Lock and shield
Manifold
HF
Faucet, hose
Manifold, globe check
Manifold, globe check, deck operated
Check, ball
Check, lift
Check, swing
General symbol, relief
Safety, boiler



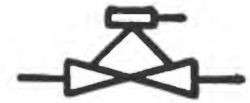
Proportioning, three-way



Pump governor



Solenoid control



Thermostatically controlled

VALVE JOINTS

Flanged ends

Screwed ends

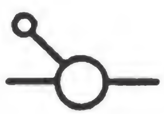
Bell-and-spigot ends

Welded and brazed ends

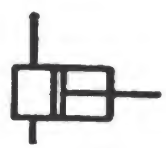
Soldered ends

PUMPS

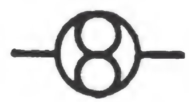
Pump, centrifugal



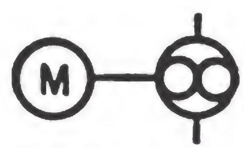
Pump, hand



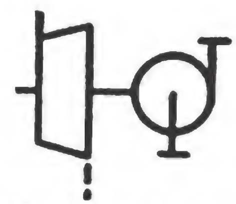
Pump, reciprocating



Pump, rotary and screw



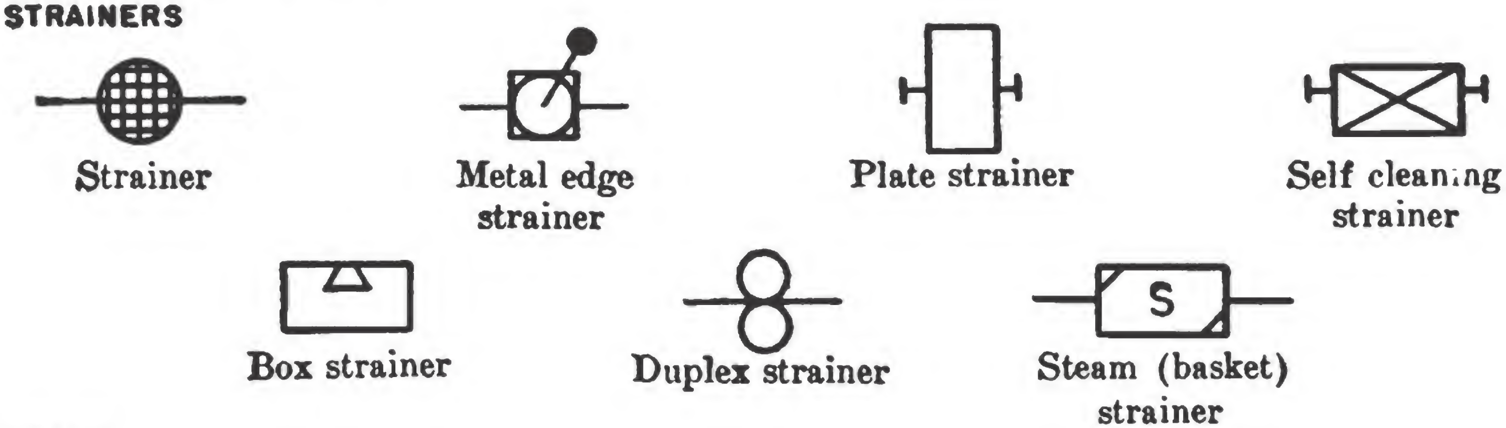
Motor driven rotary pump



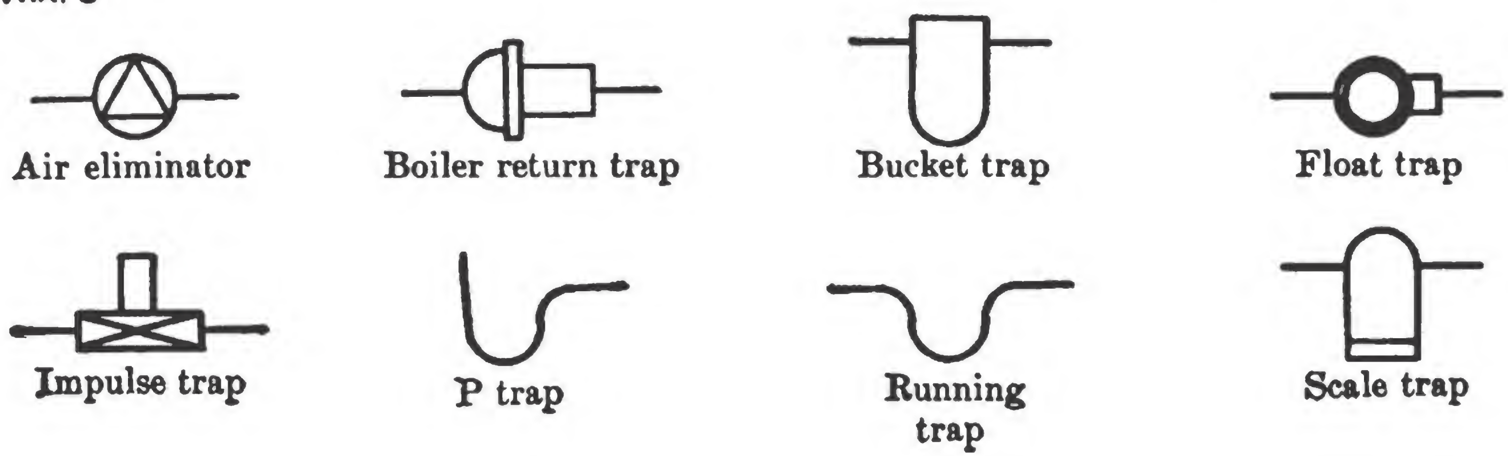
Turbine driven centrifugal pump

5. Strainers, traps, and drains

STRAINERS

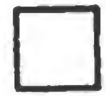


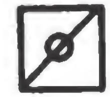
TRAPS




Thermostatic blast trap

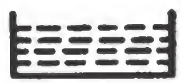

Thermostatic trap

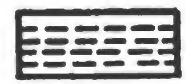

D
Drain


Drain, deck, with valve

6. Tanks, sea chests, and eductor

TANKS


Tank, open

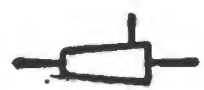

Tank, closed

SEA CHESTS


Sea chest, discharge

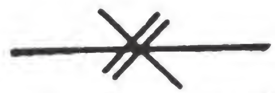

Sea chest, suction

EDUCTOR


Eductor

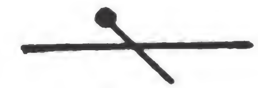
7. Ductwork for ventilation

CLOSURES



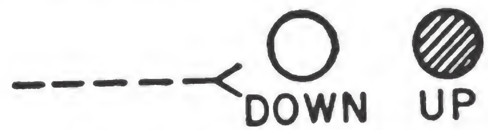
Closure, watertight,
horizontal

Closure, watertight,
vertical

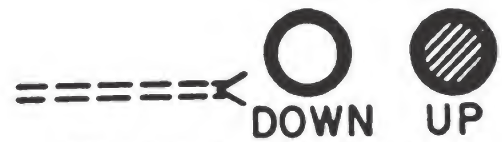


Damper

EXHAUST SYSTEMS

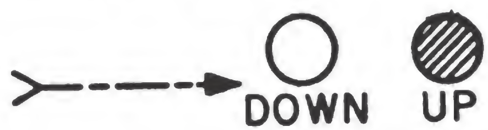


Duct, exhaust system,
nonwatertight

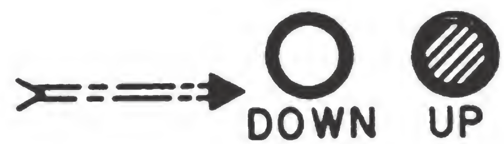


Duct, exhaust system,
watertight

RECIRCULATING SYSTEMS

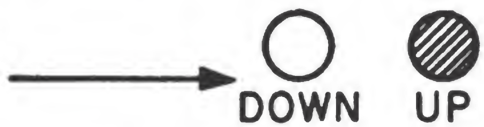


Duct, recirculating system,
nonwatertight

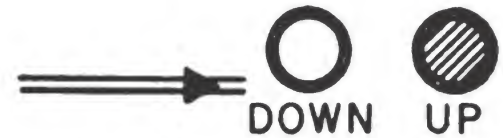


Duct, recirculating system,
watertight

SUPPLY SYSTEMS

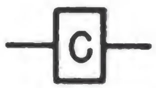


Duct, supply system, nonwatertight



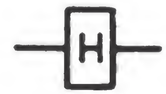
Duct, supply system, watertight

EQUIPMENT

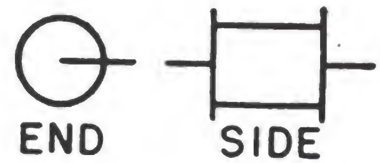


Cooling coil, duct type

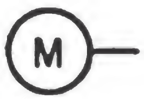
Heater, convection



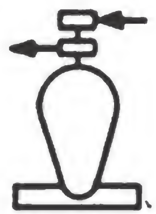
Heater, duct type

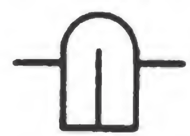


Fan, axial, in duct

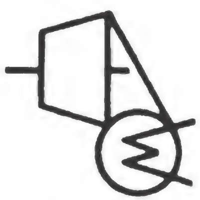


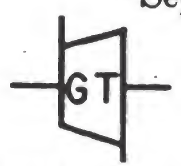
Motor


Purifier, centrifugal

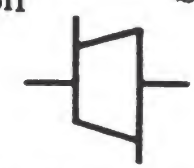

Separator, oil


Separator, steam

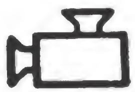

Turbine, condensing



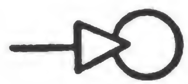
Turbine, gas


Turbine, steam

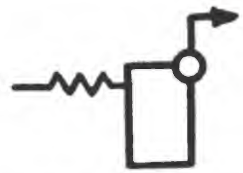
MECHANICAL AND POWER SYMBOLS



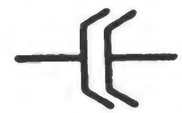
Blower



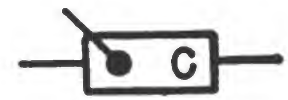
Blower, soot



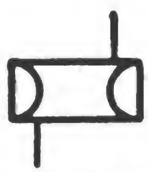
Boiler, steam generator (with economizer)



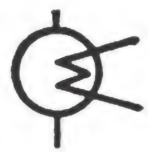
Clutch, all types



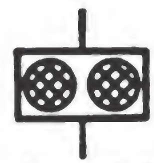
Combustion chamber, gas turbine



Compressor, rotary, blower vane type roots



Condenser, surface

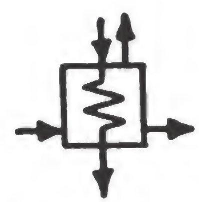


Duplex oil filter

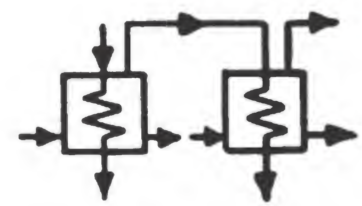
Engine, diesel

Engine, gas

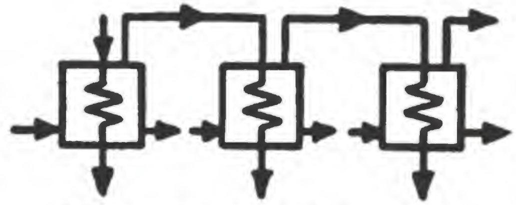
Engine, steam

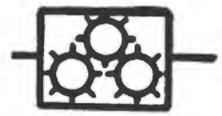


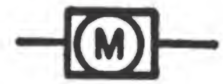
Evaporator, single effect



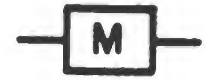
Evaporator, double effect


Evaporator, triple effect


Gear train, all types

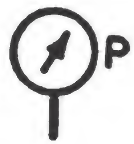


Meter, area type (other than electrical)

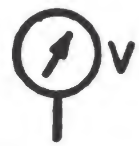


Meter, displacement type (other than electrical)

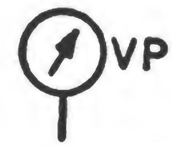
GAGES



Pressure



Vacuum

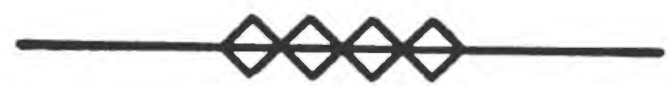


Vacuum-pressure


Thermometer

AERONAUTICAL PIPING SYMBOLS

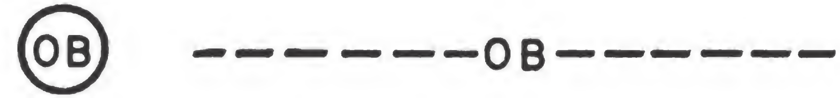
1. Tube and hose line designations

Service	*Riser or stack*	*Symbol*
Bellows		

Bleed return	BR	- - - - - - - - BR - - - - - - - -
Drain	D	———————— D ————————
Engine coolant	EC	———————— EC ————————
Foam solution	FO	———————— FOAM ————————
Fuel oil vent	FOV	- - - - - - - - FOV - - - - - - - -
Fuel supply	F	———————— F ————————

Lubricating oil

Oil breather

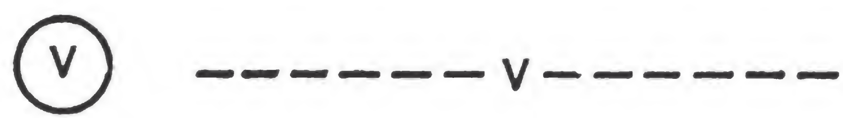


Pneumatic

Self-sealing

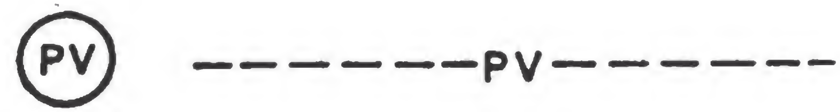
Vacuum

Vent

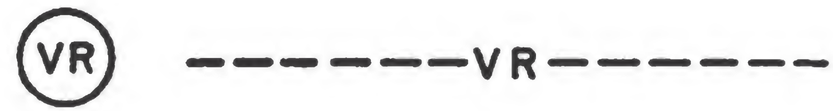


932348°—51——12

Vent, pressure

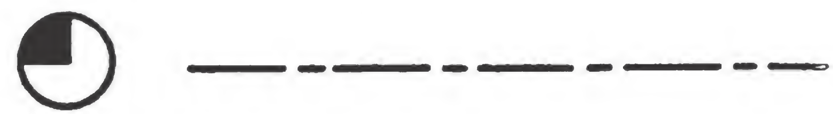


Vent, return

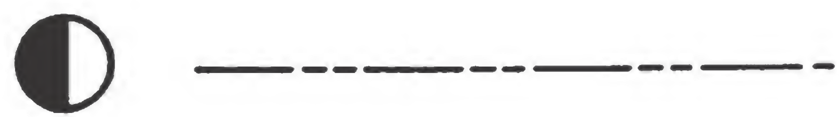


Water injection

Water, cold



Water, hot



9. Hydraulic tube and hose line designations

Brake

Down (or close) 

Emergency pressure 

Hose connection, rigid tubing 

Hose, flexible 

Return 

Supply, fluid, pump suction 

Suction gravity 

Supply, pressure 

Up (or open) 

Vent 

3. Oxygen tube and hose line symbols

Distribution (high pressure) 

Distribution (low pressure) 

Filler

Flexible

4. Hydraulic equipment symbols

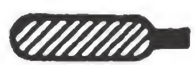
Accumulator

Brake control

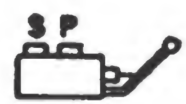
Filter or strainer

Oxygen unit, portable (continuous flow)

Oxygen unit, portable (demand)



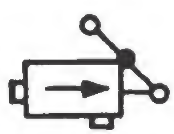
Converter, liquid oxygen



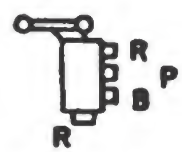
Pump, hand

Pump, power driven

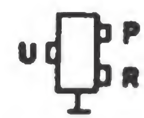
Valve, check, automatic



Valve, check, manual



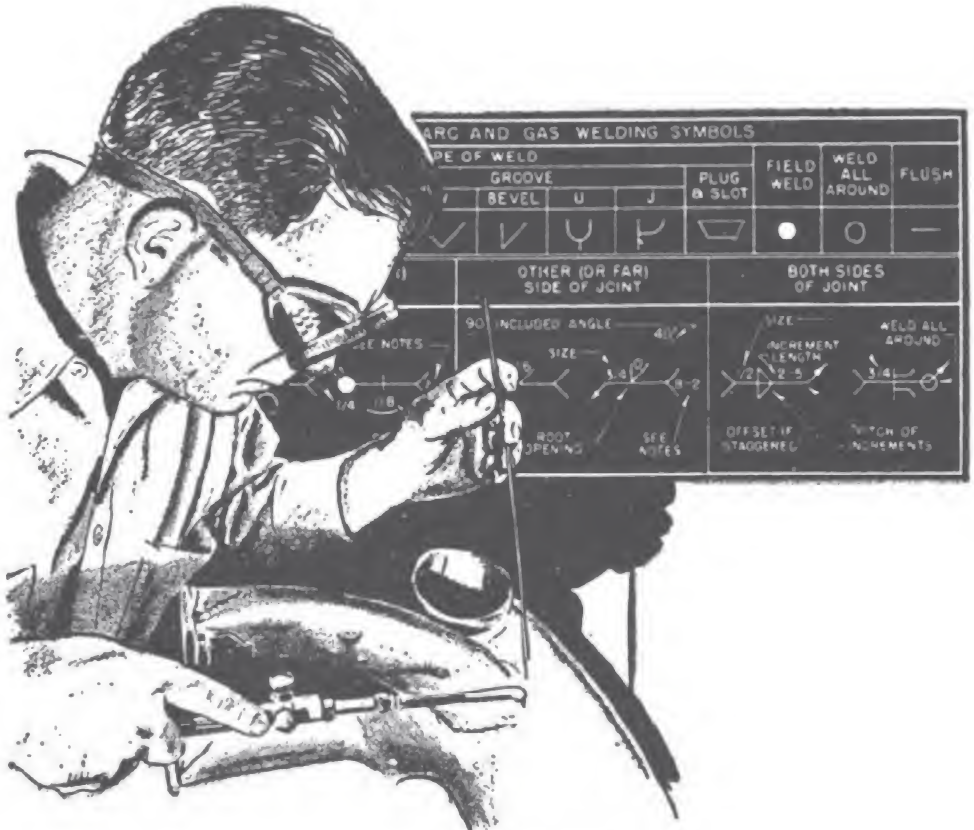
Valve, brake control



Valve, gun charger control

QUIZ

1. Do the lines indicating mechanical connections ordinarily represent the actual position of the shafting?
2. a. Referring to gears what does *P* mean? b. What does *T* mean?
3. Draw the following symbols:
   a. General valve.
   b. Duplex strainer.
   c. Bucket trap.
   d. Locked closed globe valve.



CHAPTER 14

WELDING SYMBOLS

WELD SYMBOL AND WELDING SYMBOL DEFINED

This chapter is only an introduction to the standard welding symbols which appear on modern blueprints. No attempt is made to define or explain even the few welding terms used in relation to these symbols. It is assumed that you have learned or will learn the meanings of the various welding names and processes, such as braze, resistance, flash, thermit, fillet, and so on, in the course of your welding work or in other texts.

In the Military Standards for welding terminology (and probably in most civilian usage as well) a distinction is made between the terms WELD SYMBOL and WELDING SYMBOL.

The WELD SYMBOL is a graphic (written) or picture symbol used to indicate the desired type of weld. Figures

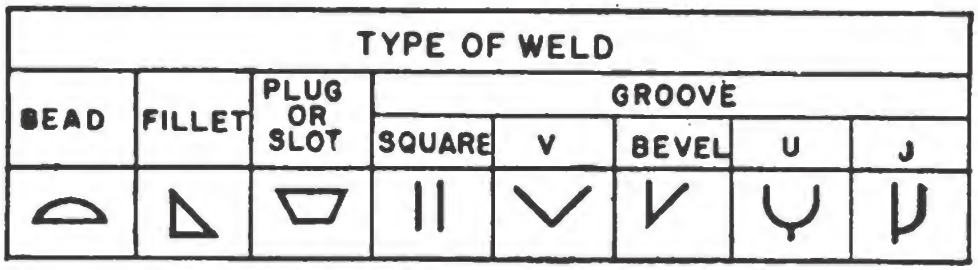


Figure 14–1.—Basic arc and gas weld symbols.

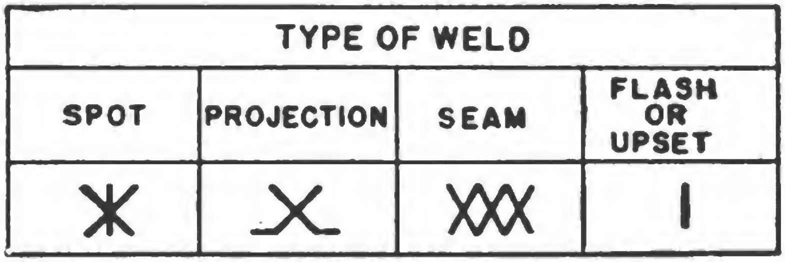


Figure 14–2.—Basic resistance weld symbols.

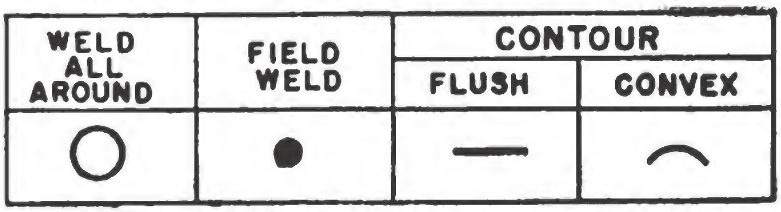


Figure 14–3.—Supplementary symbols.

14–1, 14–2, and 14–3 illustrate the basic weld symbols. Note that these weld symbols to a great extent resemble in shape the types of welds which they represent. Brazing, forge, thermit, induction, and flow welding are indicated by using a process or specification reference in the tail of the welding symbol.

The WELDING SYMBOL, on the other hand, is the assembled symbol, consisting of some or all of the following elements: Reference line, Arrow, Basic weld symbols, Dimensions and other data, Supplementary symbols, Finish symbols, Tail, Specification, process, or other reference.

These elements and their standard locations with respect to each other are illustrated in figure 14–4.

In pages 178 through 183 the left-hand page in each case illustrates various symbols and describes their use; the right-hand page shows them as they would appear on actual blueprints.

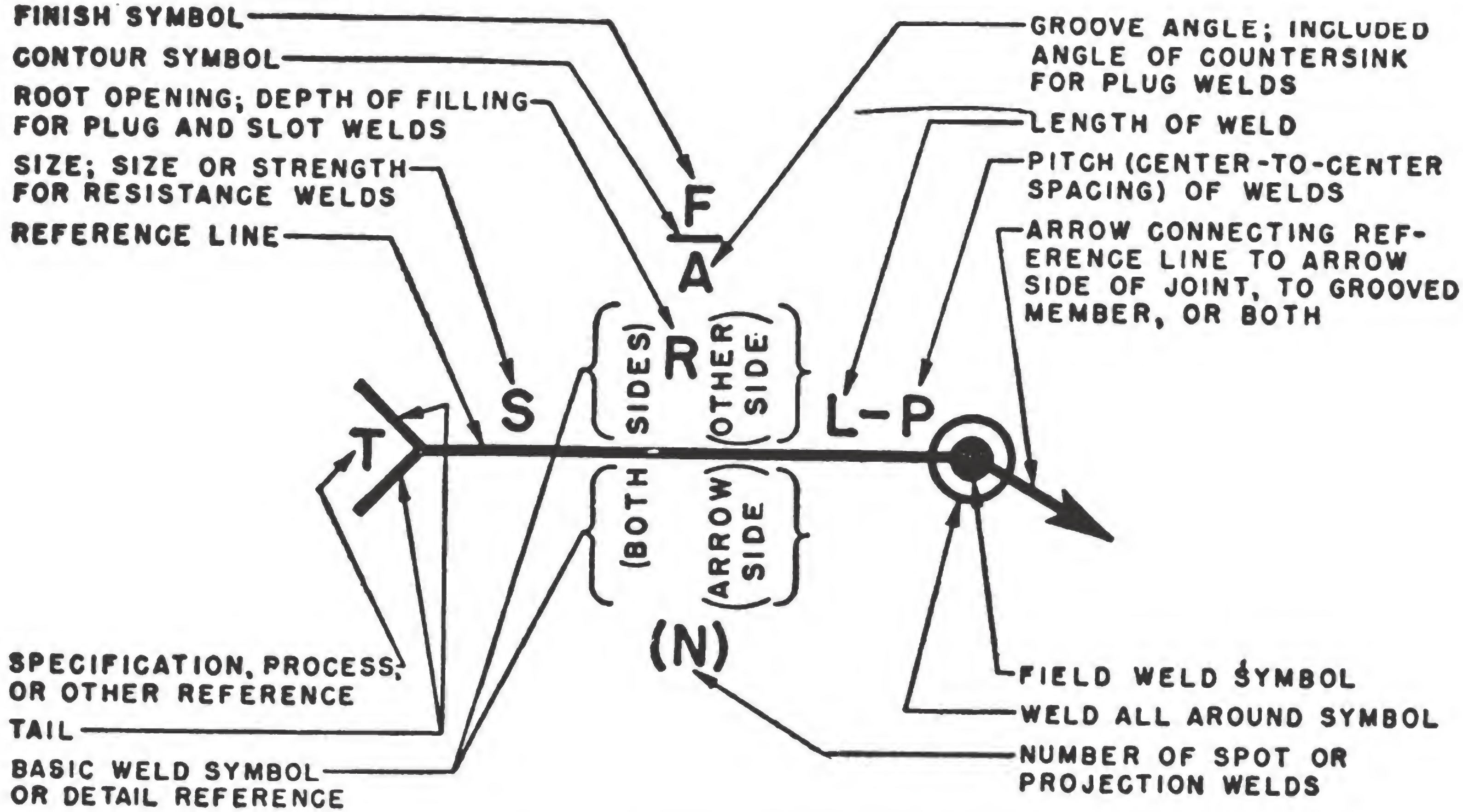


Figure 14-4.—Standard location of elements on a welding symbol.

HOW TO READ WELDING SYMBOLS

The following information is based on Joint Army-Navy or Military Standards for welding symbols. Reference to the latest JAN or MIL Standards should occasionally be made, as the Standards are subject to change from time to time. A careful study of the following rules and illustrations, plus a little thought as to their interpretation and possible variations, should enable you to meet almost any welding blueprint with confidence.

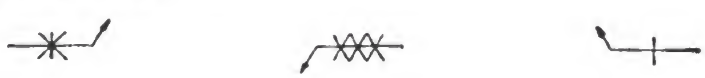
GENERAL

1. Welds on the arrow side of the joint are shown by placing the weld symbol on the side of the reference line toward the reader, as follows:

2. Welds on the other side of the joint are shown by placing the weld symbol on the side of the reference line away from the reader, as follows:

3. Welds on both sides of the joint are shown by placing weld symbols on both sides of the line, as follows:

4. Spot, seam, flash, and upset symbols are centered on the reference line, as follows:



5. A specification, process, or other reference is placed on the tail, as follows (if no reference is required, the tail is omitted):

6. General notes or specifications may be placed on the drawing, so that it will not be necessary to repeat references at the various symbols, as: "Unless otherwise indicated, all fillet welds are 5/16-inch size."

7. Welds extending completely around a joint are indicated by the weld-all-around symbol, as follows:

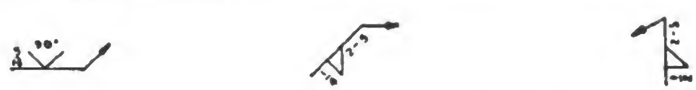
8. Field welds, that is, those made not at the place of original construction but later "in the field," are indicated by the field weld symbol, as follows:

9. Spot and seam weld symbols may be placed directly on drawings at the locations of the desired welds, as follows:

But all other weld symbols are shown only on the welding symbol reference line and never on the lines of the drawing.

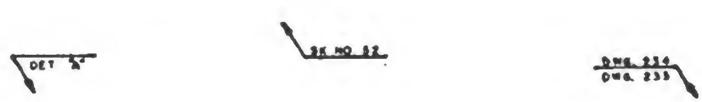
10. Fillet, bevel, and J-groove symbols are shown with the perpendicular leg always to the left, as follows:

11. Information on welding symbols is read from left to right along the reference line, as follows:



12. When joints have more than one weld, a symbol is shown for each weld, as follows:

13. When the basic weld symbols are inadequate to show all that is needed, the weld is shown by a cross section, detail, or other data with a reference thereto on the welding symbol, as follows:

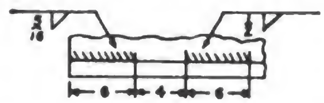


FILLET WELDS

1. The size of a fillet is shown to the left of the weld symbol. If the fillet has unequal legs, the sizes are shown in parentheses to the left of the symbol. (See figure 14–8.)

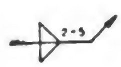
2. The length of a fillet is shown to the right of the weld symbol. If the weld extends the full length of a piece, no length dimension may be shown. (See figure 14–9, 14–10.)

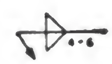
3. Hatching may be used to show the extent of fillet welding:



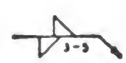
4. The pitch or center-to-center spacing of intermittent fillet welding is shown to the right of the length dimension:

5. Chain intermittent fillet welding is shown as follows:



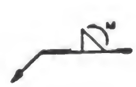


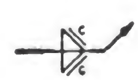
6. Staggered intermittent fillet welding is shown as follows:



7. Flat-faced welds are shown by adding the flush-contour symbol to the weld symbol:

8. Welds that are to be made flat-faced or to be finished to a convex contour by mechanical means are shown by adding both the flush-contour symbol or the convex-contour symbol and the user's standard finish symbol to the weld symbol. G indicates grinding; M, machining; and C, chipping.





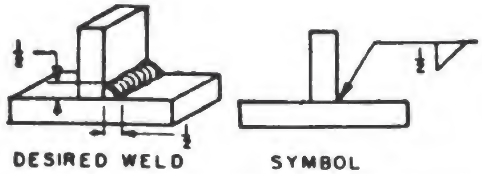


Figure 14-5.—Size of single-fillet weld.

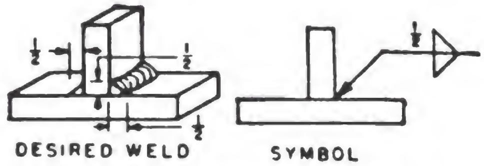


Figure 14-6.—Size of equal double-fillet welds.

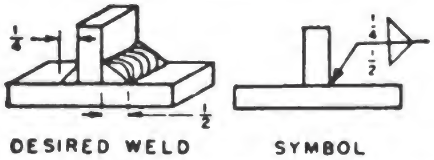


Figure 14-7.—Size of unequal double-fillet weld.

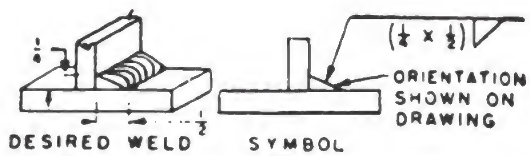


Figure 14-8.—Size of fillet weld having unequal legs.

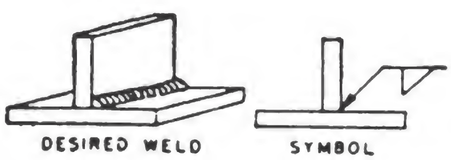


Figure 14-9.—Continuous fillet weld.

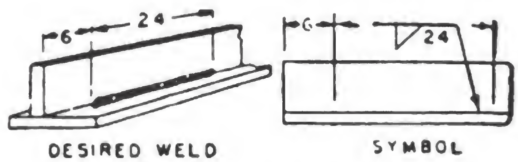


Figure 14-10.—Length of fillet weld.

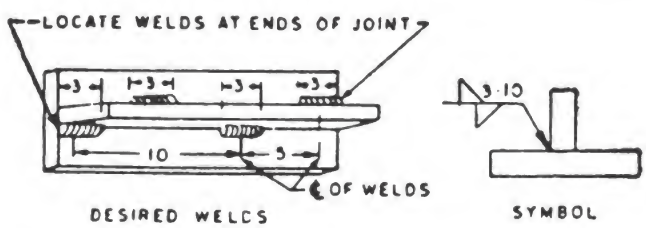


Figure 14-11.—Length and pitch of increments of staggered intermittent welding.

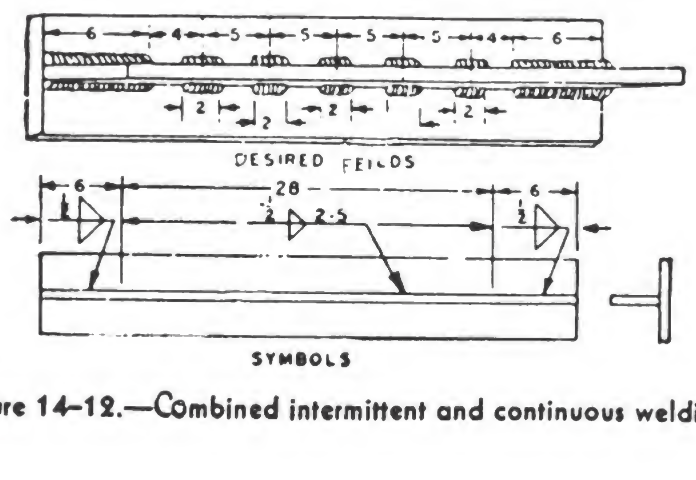
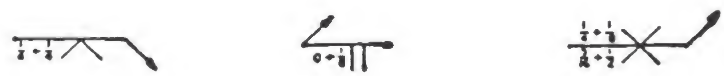


Figure 14-12.—Combined intermittent and continuous welding.

GROOVE WELDS

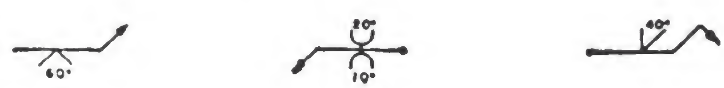
1. The size of groove welds is shown to the left of the weld symbol:

2. The depth of grooving and the root penetration are read in that order, from left to right along the reference line (separated by a plus sign):

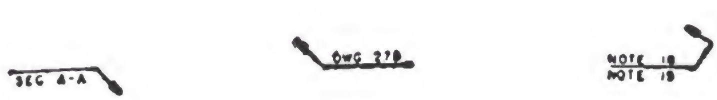


3. Root openings follow the user's standard unless otherwise indicated. When not the user's standard, the dimension of the root opening is shown inside the weld symbol:

4. The groove angles are user's standard unless otherwise indicated. When not the user's standard, the groove weld is shown as follows:



5. Groove radii and root faces of U- and J-groove welds are the user's standard unless otherwise indicated. If not the user's standard, the weld is shown by a reference, as follows:



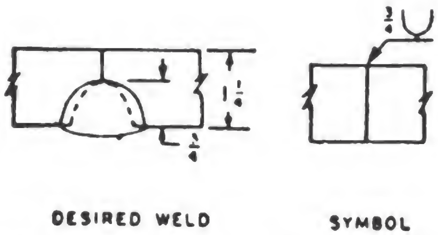


Figure 14-13.—Welds with no specified root penetration.

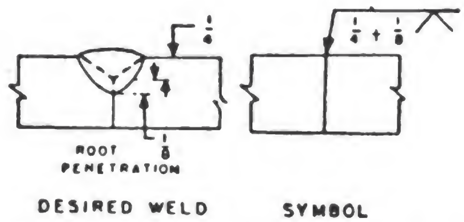


Figure 14-14.—Welds with specified root penetration.

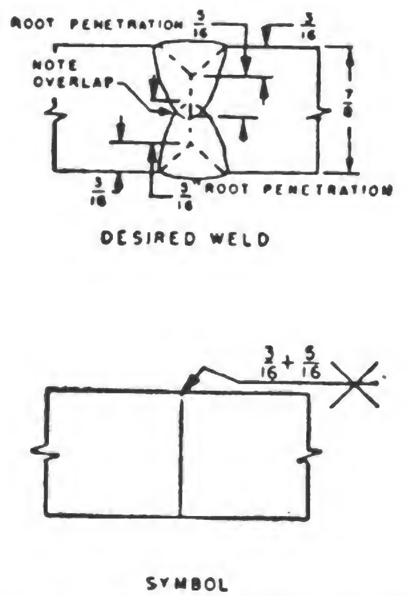


Figure 14-15.—Designation of size of groove welds with specified root penetration.

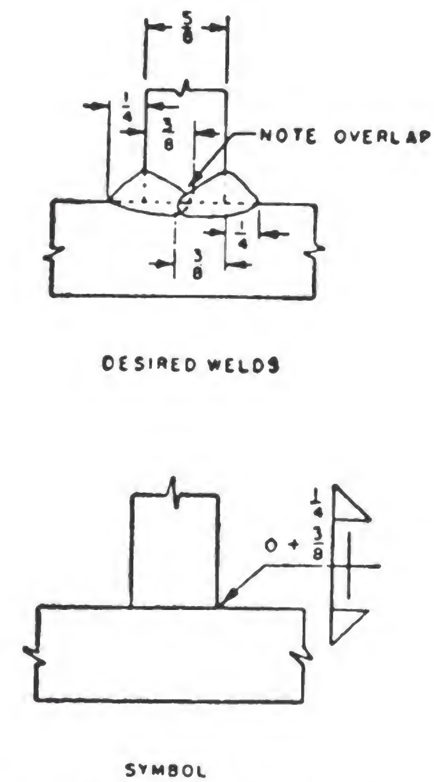


Figure 14-16.—Combined welds with specified root penetration.

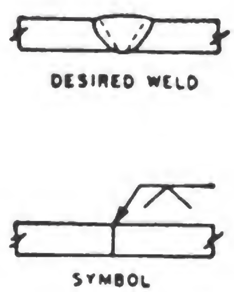


Figure 14-17.—Designation of root opening of groove welds.

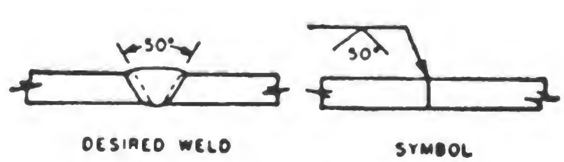


Figure 14-18.—Groove angle of groove welds.

GROOVE WELDS (Continued)

Flush and Contour

6. Flat-weld groove welds are shown by adding the flush-contour symbol to the weld symbol:

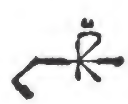


7. If the groove weld is to be made flush not only by flat-welding but by mechanical means, the user's standard finish symbol is added to the weld symbol:



8. If a groove weld is to be mechanically finished to a convex contour, both the convex-contour symbol and the user's standard finish symbol is added to the weld symbol:





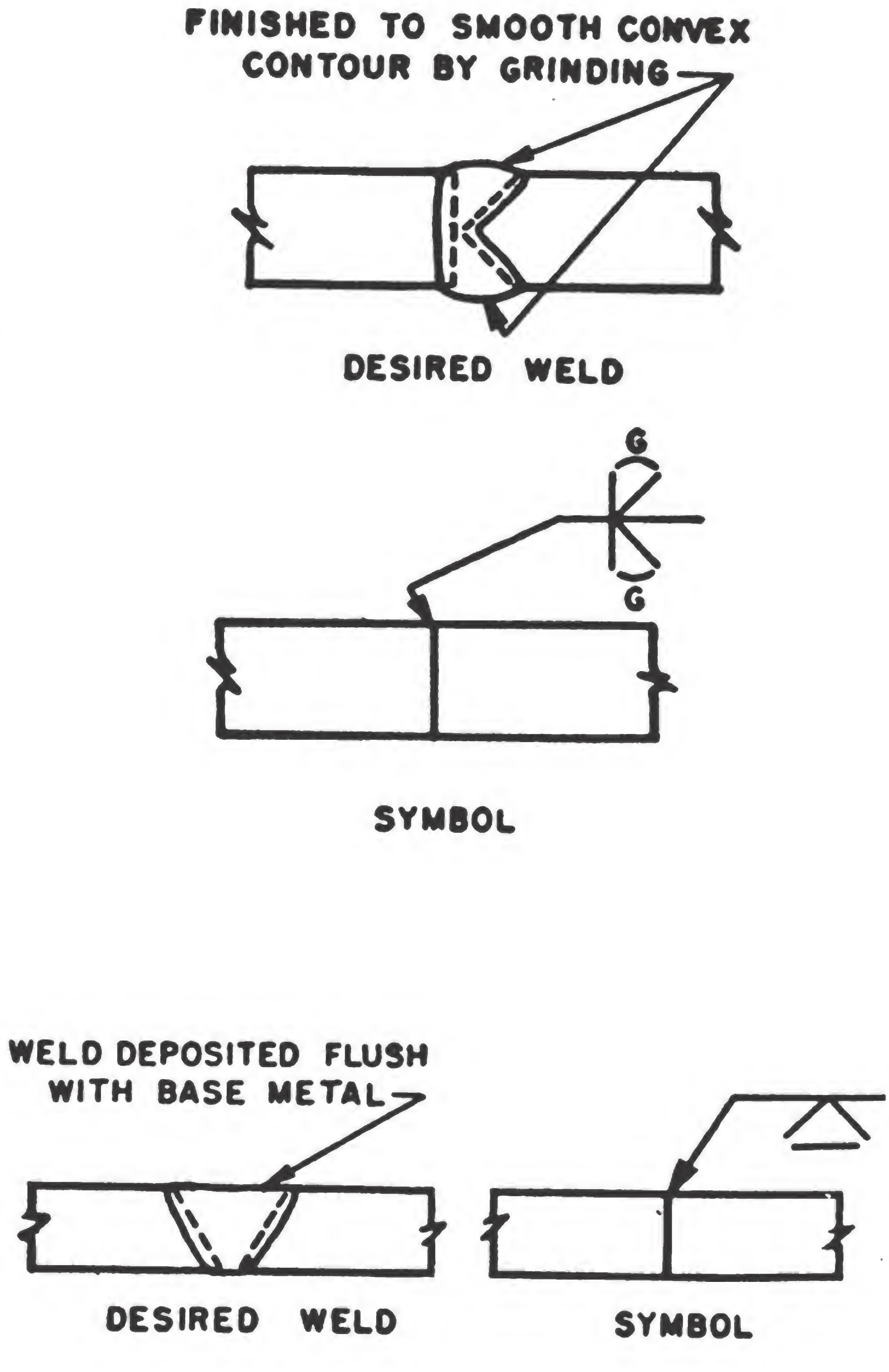


Figure 14-19.—Use of contour symbols with groove welding symbols.

932348°—51——13

BEAD WELDS (or BACK or BACKING WELDS)

1. The single bead weld symbol is used to indicate bead-type back or backing welds of single-groove welds. (See figure 14–20.) The dual bead weld symbol indicates surfaces built up by welding. (See figure 14–22.)

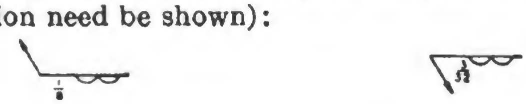
2. Bead welds used as backing welds are shown by placing a single bead weld symbol on the side of the reference line opposite the groove weld symbol:

3. No dimensions are shown on the welding symbol for bead welds used as back or backing welds. If such dimensions are to be specified, they are so stated on the drawing.

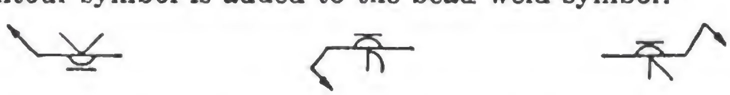
4. The dual bead weld symbol is used to indicate surfaces that are to be built up by welding:

5. Since the dual bead symbol does not indicate a joint, it has no arrow- or other-side significance. The symbol is drawn on the side of the reference line toward the reader, and the arrow points directly to the surface on which the weld is to be deposited. (See figure 14–22.)

6. Dimensions used with the dual bead symbol are shown on the same side as the weld symbol. The size of the surface to be built up is indicated by showing the minimum height of the weld deposit to the left of the weld symbol, as follows (when no specific height is desired, no size dimension need be shown):



7. When backing welds are to be welded approximately flush, the flush-contour symbol is added to the bead weld symbol:



8. When bead welds or backing welds are to be made flush or finished to a convex contour by mechanical means, both the flush-contour symbol or the convex-contour symbol and the user's standard finish symbol are added to the bead weld symbol, thus:

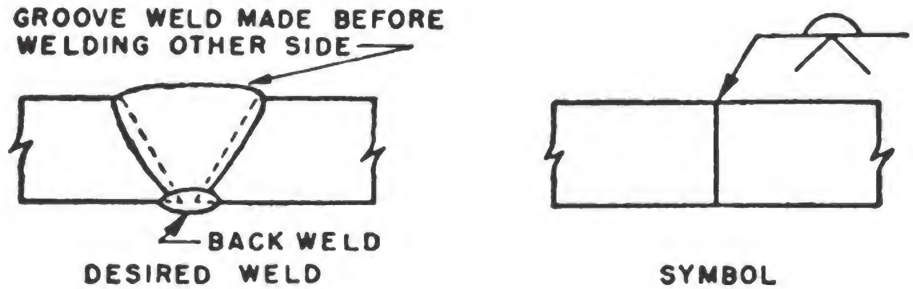


Figure 14-20.—Use of bead weld symbol to indicate single-pass back weld.

Figure 14-21.—Bead, single-J-groove and fillet weld symbols.

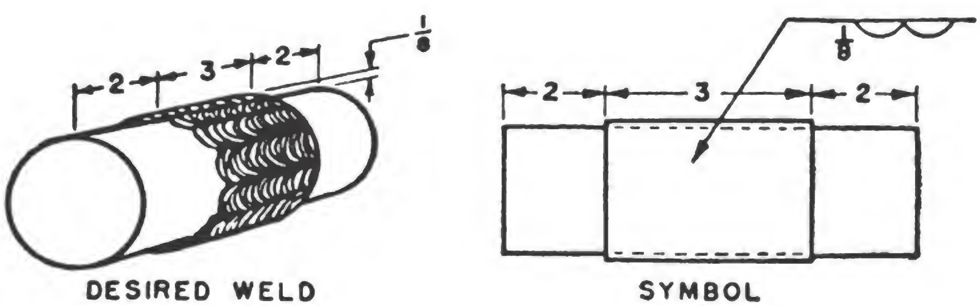


Figure 14-22.—Portion of surface built up by welding.

PLUG WELDS

1. The plug weld symbol is never used to designate fillet welds in holes. Fillet welds in holes and slots are shown by means of the fillet welding symbols.

2. If the hole to be plug welded is on the arrow side, the weld symbol is placed on the side of the reference line toward the reader, as shown in figure 14–23.

3. If the hole is in the other-side member of a joint, the weld symbol is placed on the reference line away from the reader, as shown in figure 14–24.

4. The size of a plug weld is shown to the left of the weld symbol, as follows:

5. The included angle of countersink of the plug weld is the user's standard unless otherwise indicated. If not that of the user, the included angle is shown as follows:

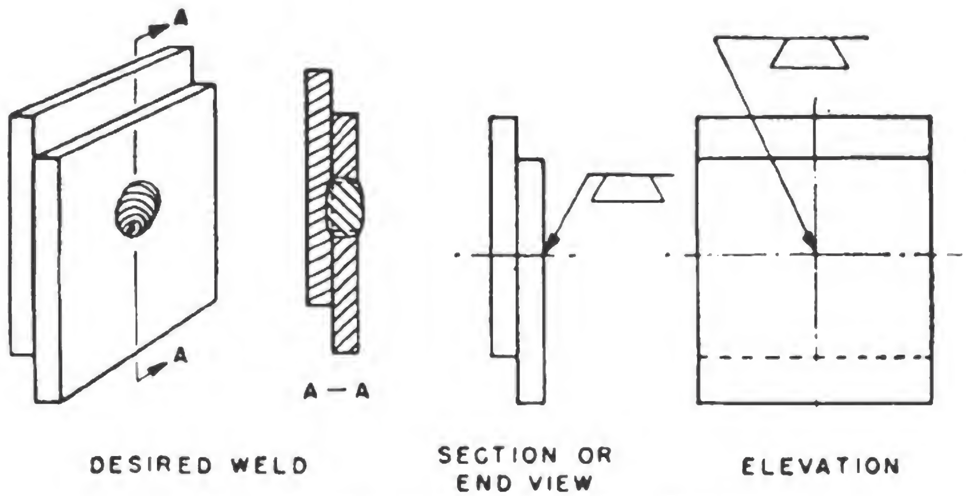


Figure 14-23.—Use of arrow-side plug welding symbol.

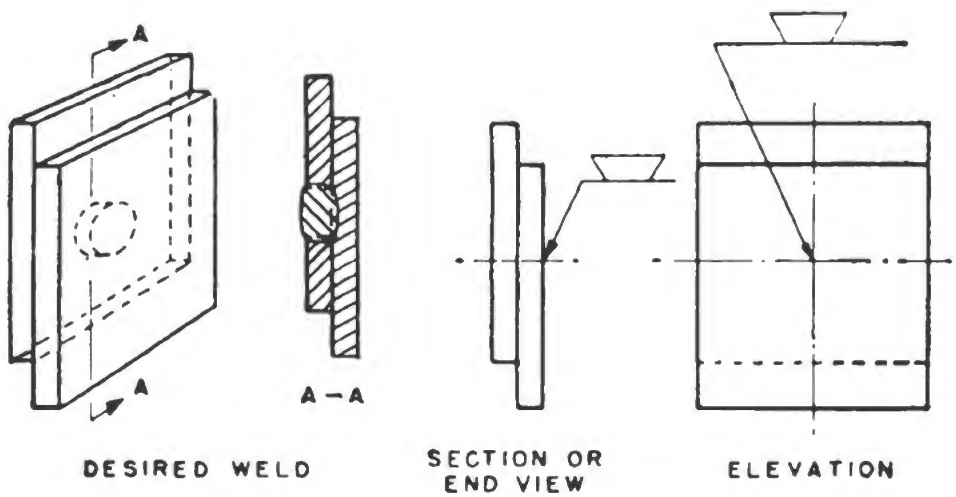


Figure 14-24.—Use of other-side plug welding symbol.

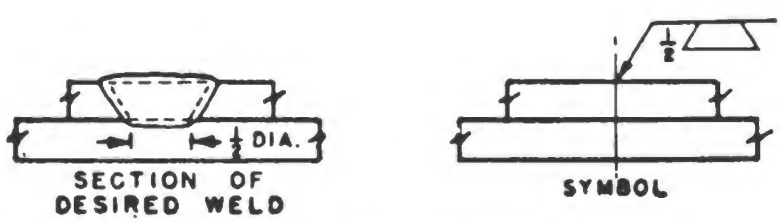


Figure 14-25.—Size of plug weld.

PLUG WELDS (Continued)

6. The depth of filling of a plug weld is complete unless otherwise indicated. If the filling is to be less than complete, the depth of filling, in inches, is shown inside the weld symbol, as follows:

7. The pitch, that is, the center-to-center spacing, of plug welds is shown to the right of the weld symbol:

8. The flush-contour symbol is added to the weld symbol when a plug weld is to be welded approximately flush without using any method of machining, as follows:

9. If a plug weld is to be made flush by mechanical means, both the flush-contour symbol and the user's standard finish symbol are added to the weld symbol, as follows:

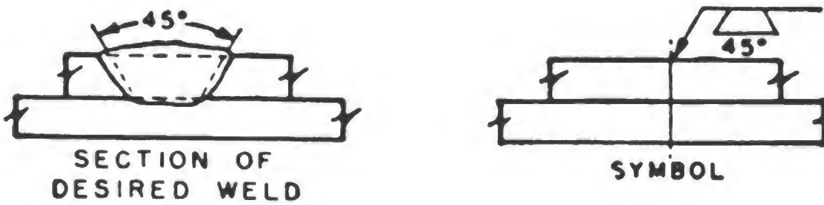


Figure 14-26.—Included angle of countersink of plug welds.

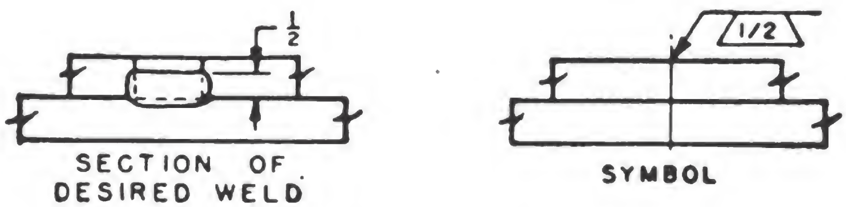


Figure 14-27.—Depth of filling of plug welds.

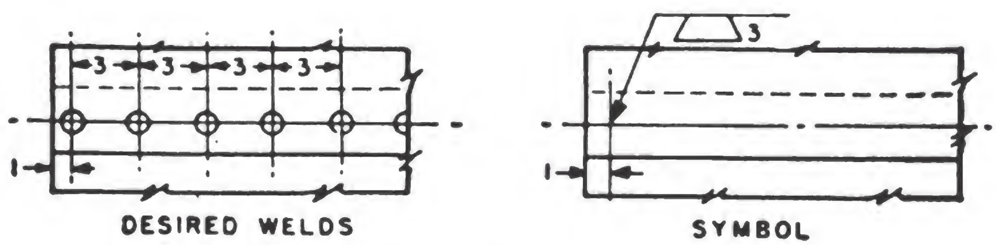


Figure 14-28.—Pitch of plug welds.

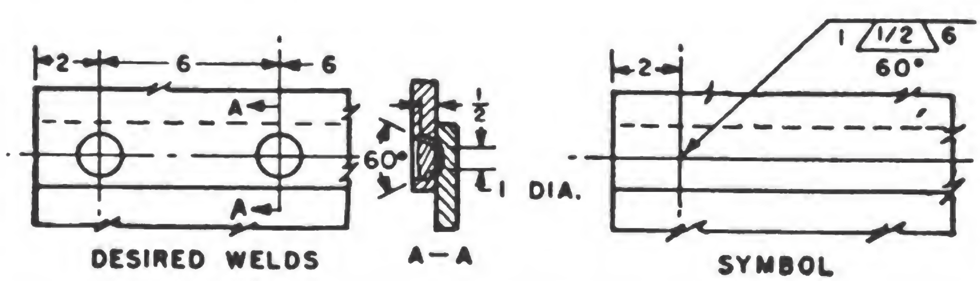
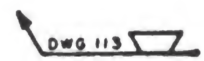


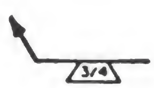
Figure 14-29.—Plug welding symbol showing use of combined dimensions.

SLOT WELDS

1. The weld symb for a slot weld is the same as that for a plug weld. (Its meaning is clearly shown by the slot hole on the drawing.) But the length, width, spacing, included angle of countersink, orientation, and location of slot welds cannot be shown on the welding symbol. These data are shown on the drawing or by a detail, with a reference on the welding symbol, as follows:



2. The depth of the filling, however, may be indicated. If the slot is completely filled, no notation is made. When the depth of filling is less than complete, the depth of filling in inches is shown inside the weld symbol, as follows:



3. Slots in the arrow-side member of a joint for slot welding are indicated by placing the weld symbol on the side of the reference line toward the reader. (See figure 14–30.)

4. Slots in the other-side member of a joint for slot welding are indicated by placing the weld symbol on the side of the reference line away from the reader. (See figure 14–31.)

5. The slot weld symbol is never used to designate fillet welds in slots.

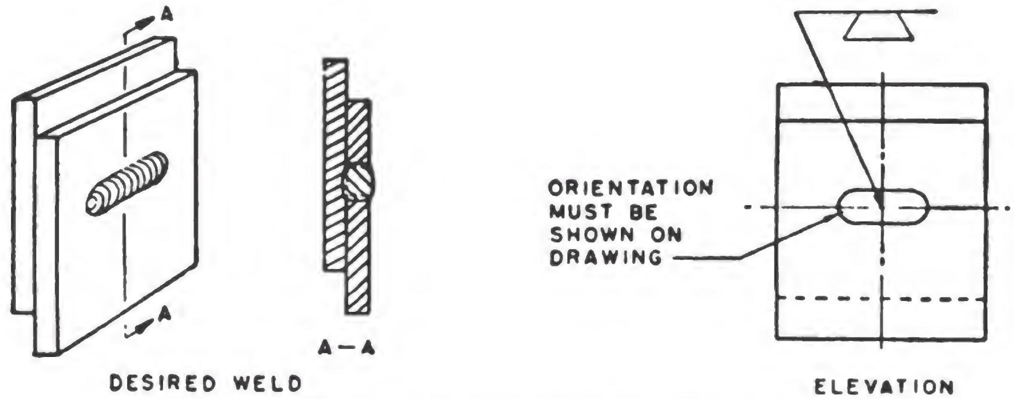


Figure 14–30.—Use of arrow-side slot welding symbol.

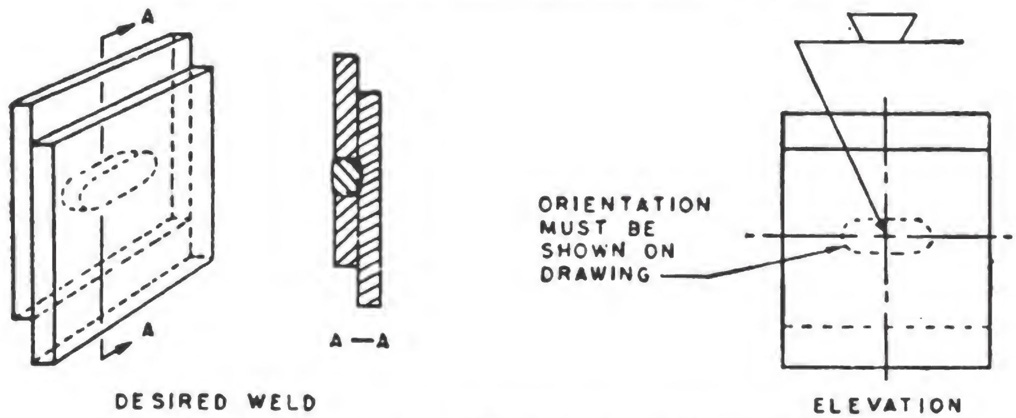


Figure 14–31.—Use of other-side slot welding symbol.

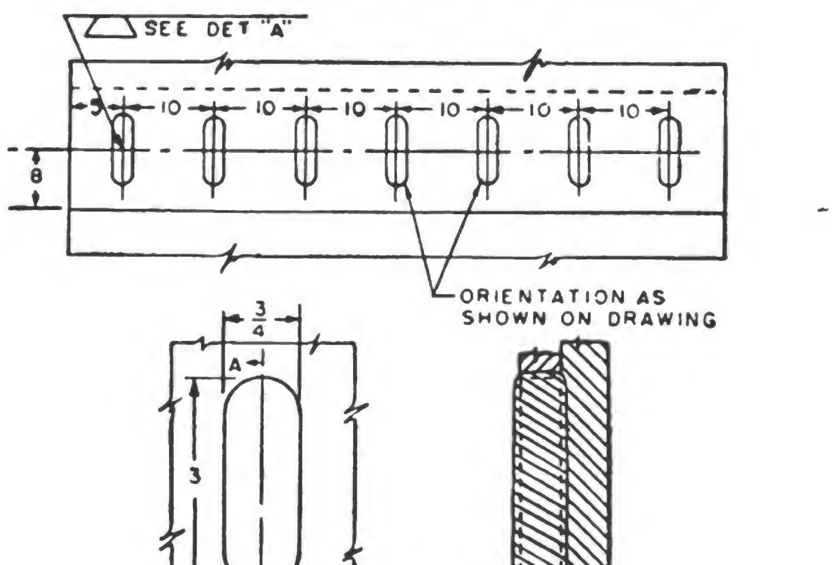
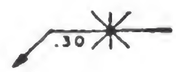


Figure 14–32.—Completely filled slot welds.

SPOT WELDS

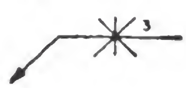
1. Spot weld symbols have no arrow- or other-side significance in themselves. Other symbols used along with spot symbols may have such significance. Spot weld symbols are centered on the reference line. The dimensions may be shown on either side of the reference line.

2. Spot welds are dimensioned either by size or strength. The size is designated as the diameter of the weld expressed decimally in hundredths of an inch and is shown with inch marks to the left of the weld symbol, as follows:

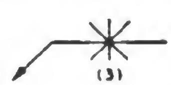


3. The strength of spot welds is designated as the minimum acceptable shear strength in pounds per spot and is shown to the left of the weld symbol, as follows:

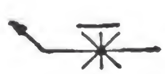
4. The pitch (center-to-center spacing) of spot welds is shown to the right of the weld symbol, shown below. (When spot weld symbols are shown directly on the drawing, the spacing is shown by dimensions, as in figure 14–37.)

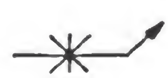


5. When a definite number of spot welds is desired, the number is shown in parentheses, above or below the symbol, as follows:



6. When the exposed surface of one member of a spot-welded joint is to be flush, that surface is indicated by adding the flush-contour symbol to the weld symbol, observing the proper location significance, as follows:





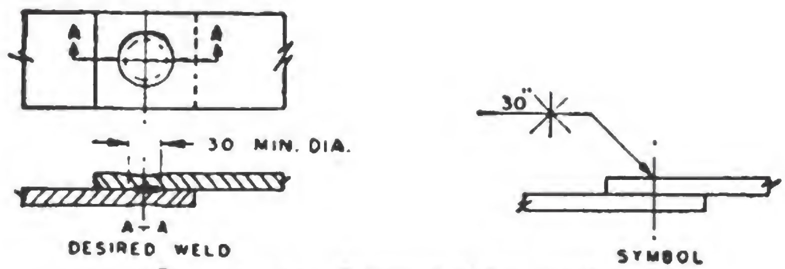


Figure 14-33.—Diameter of spot welds.

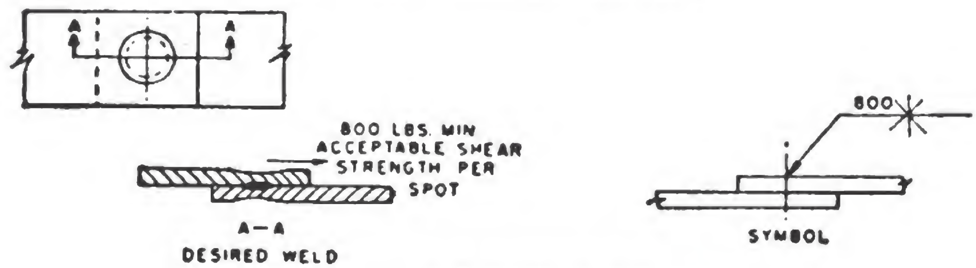


Figure 14-34.—Shear strength of spot welds.

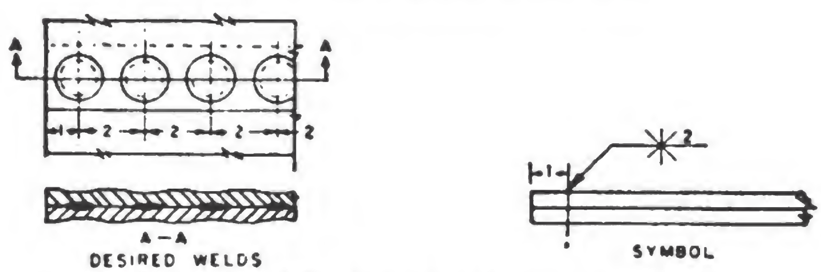


Figure 14-35.—Pitch of spot welds shown on symbol.

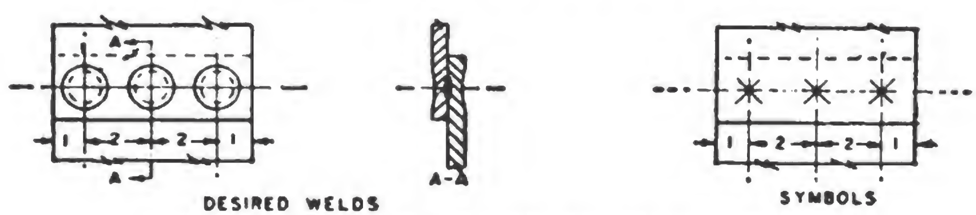


Figure 14-36.—Pitch of spot welds with symbols on drawing.

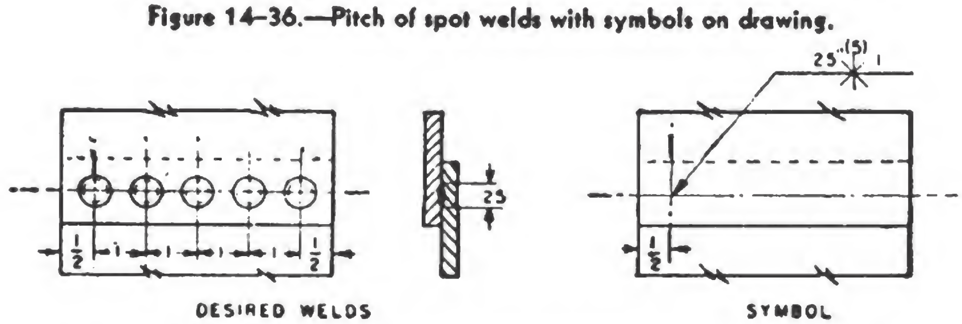
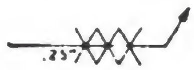


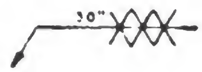
Figure 14-37.—Spot welding symbol showing use of combined dimensions.

SEAM WELDS

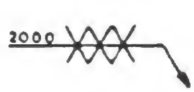
1. Seam weld symbols have no arrow- or other-side significance in themselves. Other symbols used with them may have such significance. Seam weld symbols are centered on the reference line. Their dimensions may be shown on either side of the reference line.

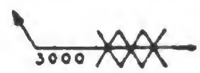
2. Seam welds are dimensioned either by size or by strength. The size of the weld is designated as the width of the weld expressed decimally in hundredths of an inch and is shown with inch marks to the left of the weld symbol:



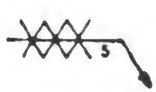


3. The strength of seam welds is designated as the minimum acceptable shear strength in pounds per linear inch and is shown to the left of the weld symbol:

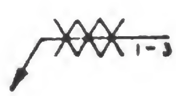




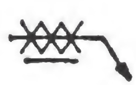
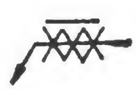
4. The length of a seam weld, when indicated, is shown to the right of the weld symbol:



5. The pitch (center-to-center spacing) of intermittent seam welding is shown as the distance between centers of the welds and is placed to the right of the length dimension.



6. When the exposed surface of one member of a seam-welded joint is to be flush, that surface is indicated by adding the flush-contour symbol to the weld symbol, observing the proper location, as follows:

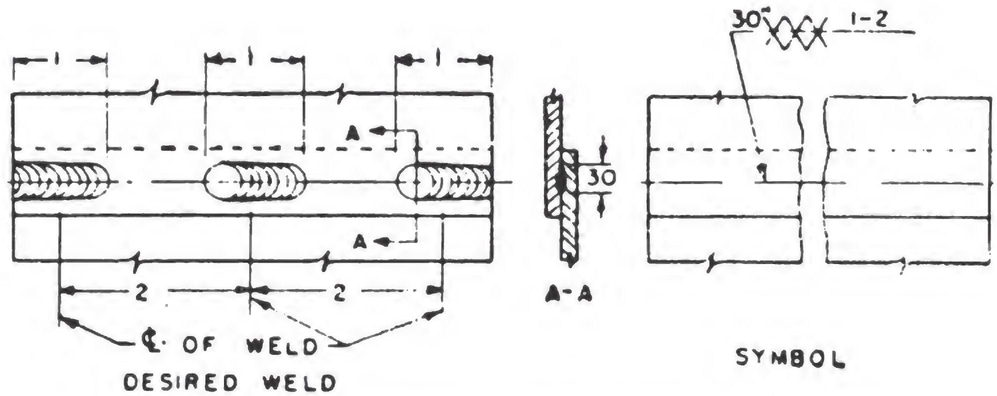


Figure 14-38.—Length and pitch of intermittent seam welds.

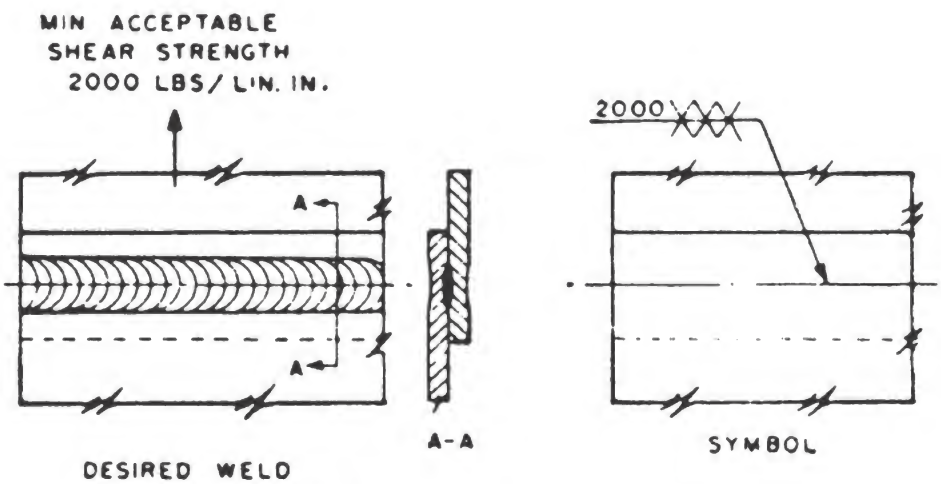


Figure 14-39.—Strength of seam welds.

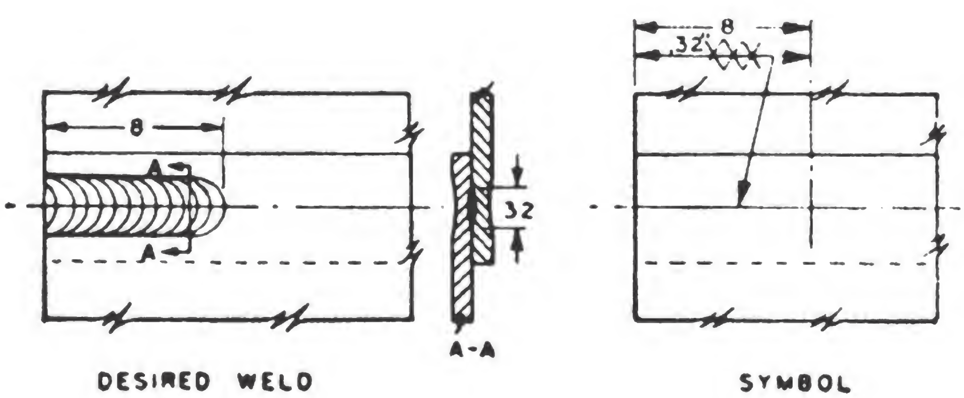
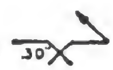


Figure 14-40.—Extent of seam welds.

PROJECTION WELDS

1. When the embossment is on the arrow-side of the joint, the weld symbol is placed on the side of the line toward the reader. When it is on the other side, the symbol appears on the side of the reference line away from the reader. The proportions of the projections are shown by a detail or other suitable means.

2. Projection welds are dimensioned either by size or by strength. The size is designated as the diameter of the weld expressed decimally in hundredths of an inch and is shown with inch marks to the left of the symbol:



3. The strength of projection welds is designated as the minimum acceptable shear strength in pounds per weld and is shown to the left of the symbol:

4. The pitch (center-to-center spacing) of projection welds is shown to the right of the weld symbol:

5. When a definite number of welds is desired, the number is shown in parentheses:

6. When the exposed surface of one member of a projection-welded joint is to be flush, that surface is indicated by adding the flush-contour symbol to the weld symbol, in accordance with the usual location significance:

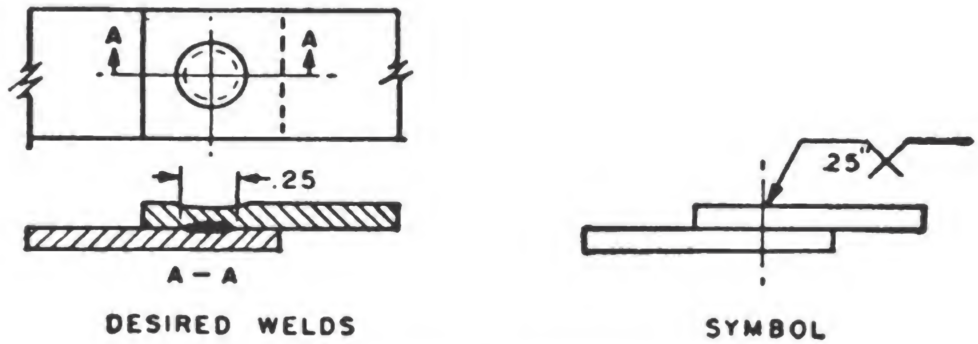



Figure 14-41.—Diameter of projection welds.

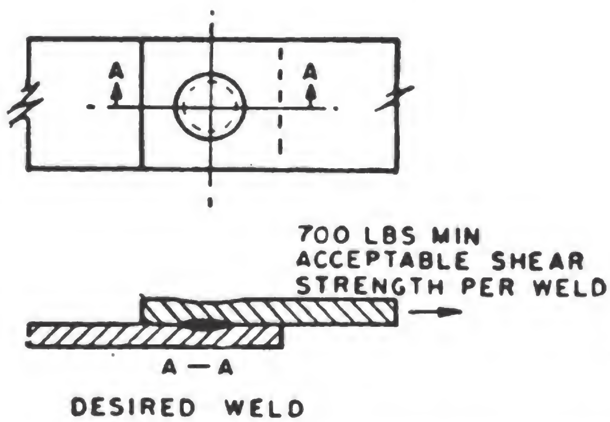


Figure 14-42.—Shear strength of projection welds.

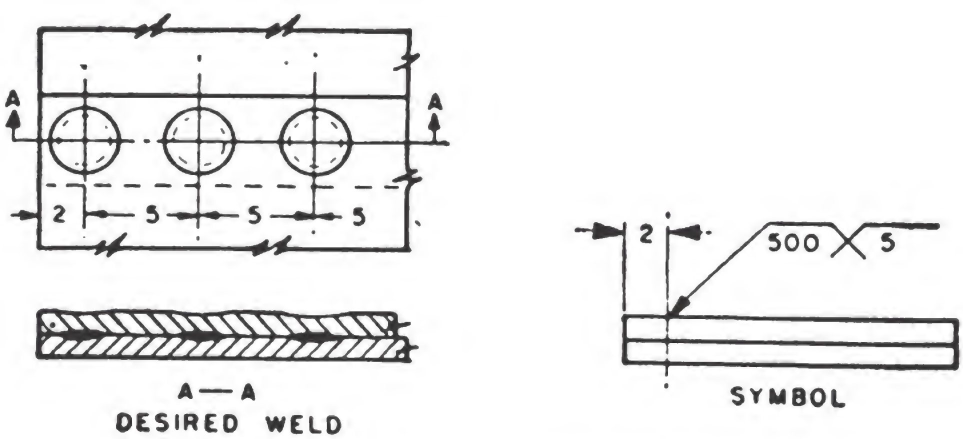


Figure 14-43.—Pitch of projection welds.

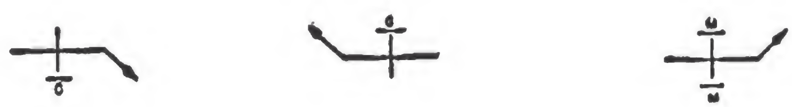
FLASH AND UPSET WELDS

1. Flush and upset weld symbols have no arrow- or other-side significance in themselves. Other symbols used along with them may have such significance.

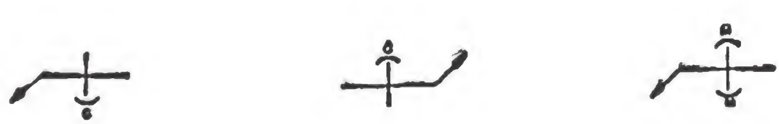
2. Flash or upset weld symbols are centered on the reference line.

3. No dimensions for flash and upset welds are shown on the welding symbol.

4. Flash and upset welds that are to be made flush by mechanical means are shown by adding both the flush-contour symbol and the user's standard finish symbol to the weld symbol, keeping the usual location significance, as follows:



5. Flash and upset welds that are to be mechanically finished to a convex contour add both the convex-contour symbol and the user's standard finish symbol to the weld symbol. The usual location significance is observed as follows:



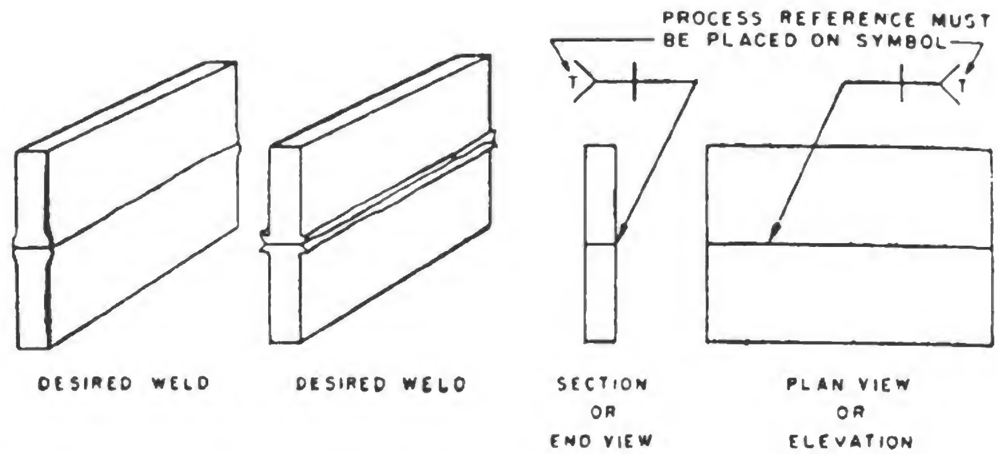


Figure 14-44.—Flash or upset welding symbol—no arrow- or other-side significance.

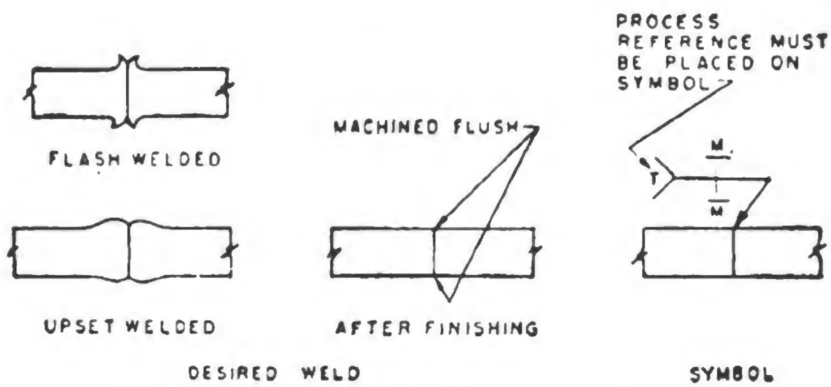


Figure 14-45.—Flash and upset welds finished flush.

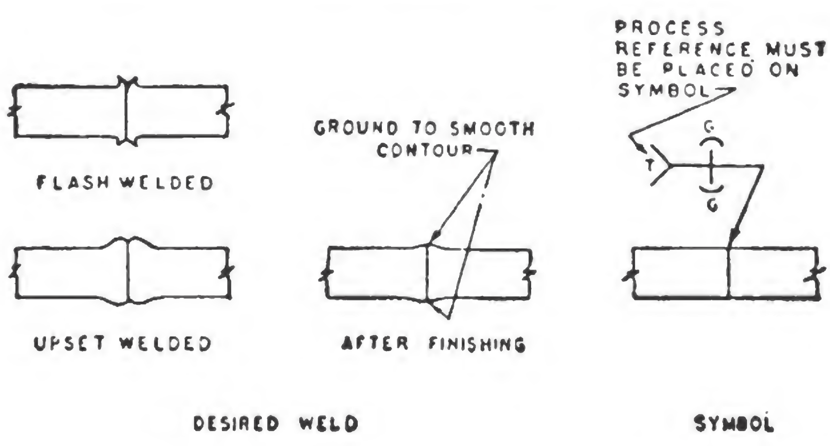


Figure 14-46.—Flash and upset welds finished to smooth contour.

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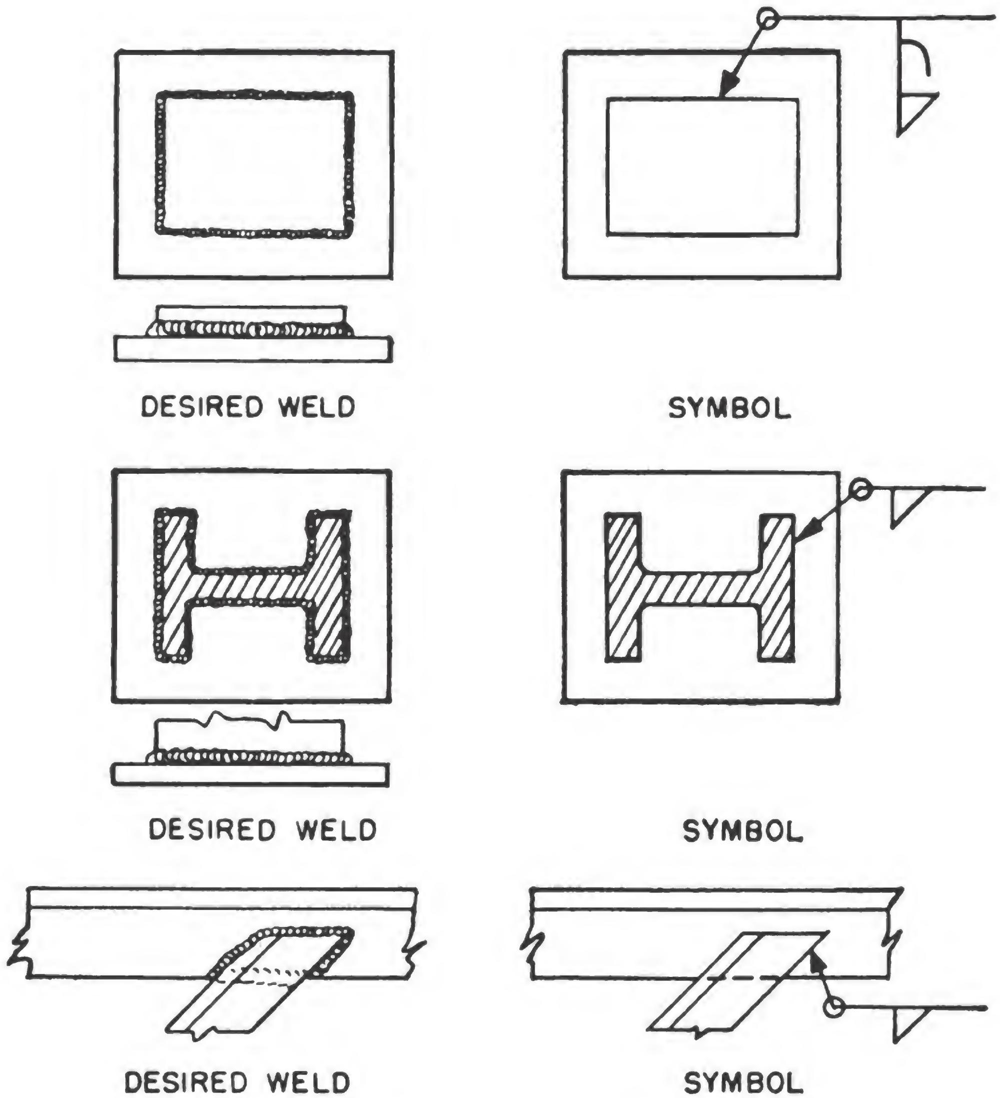


Figure 14-47.—Use of the weld-all-around symbol.

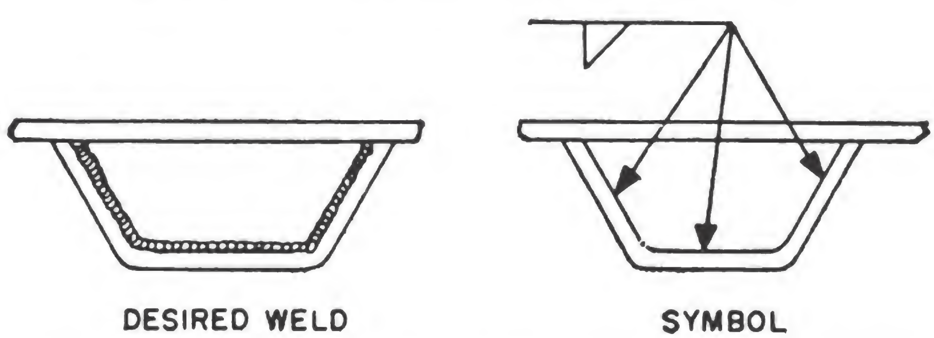
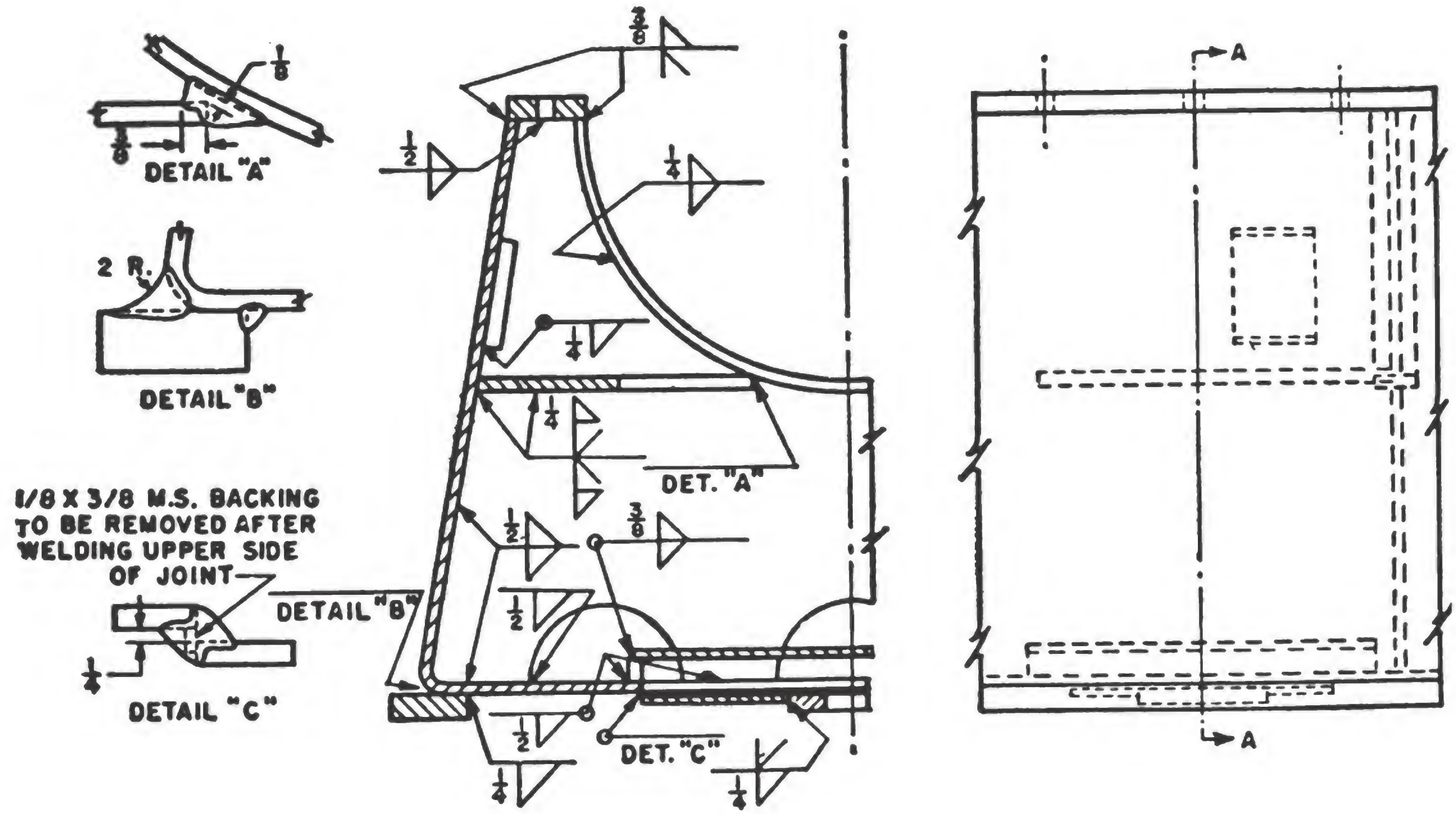


Figure 14-48.—Designating a weld with abrupt changes of direction.



SECTION A–A

Figure 14–49.—Use of arc and gas welding symbols on machinery drawing.

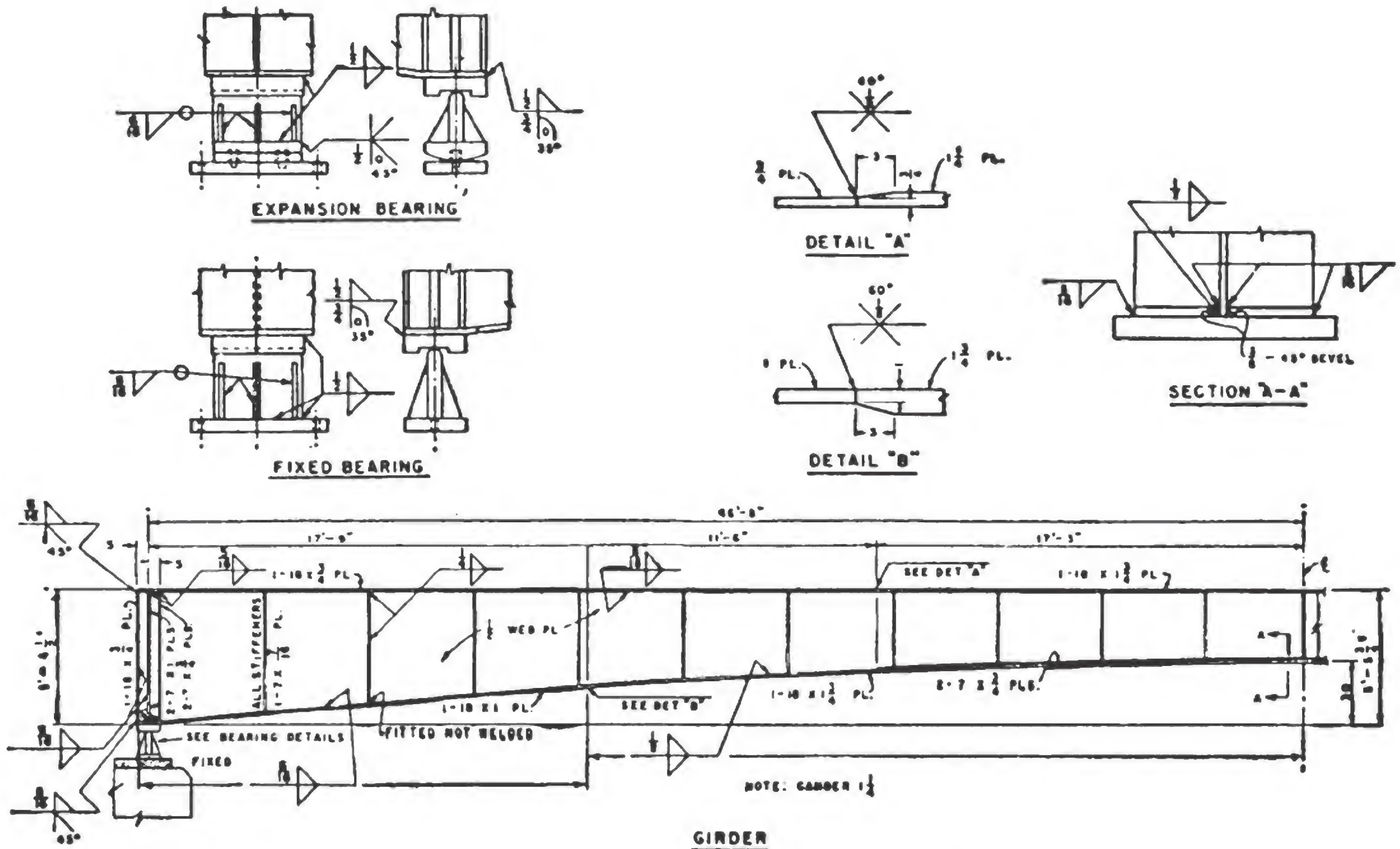
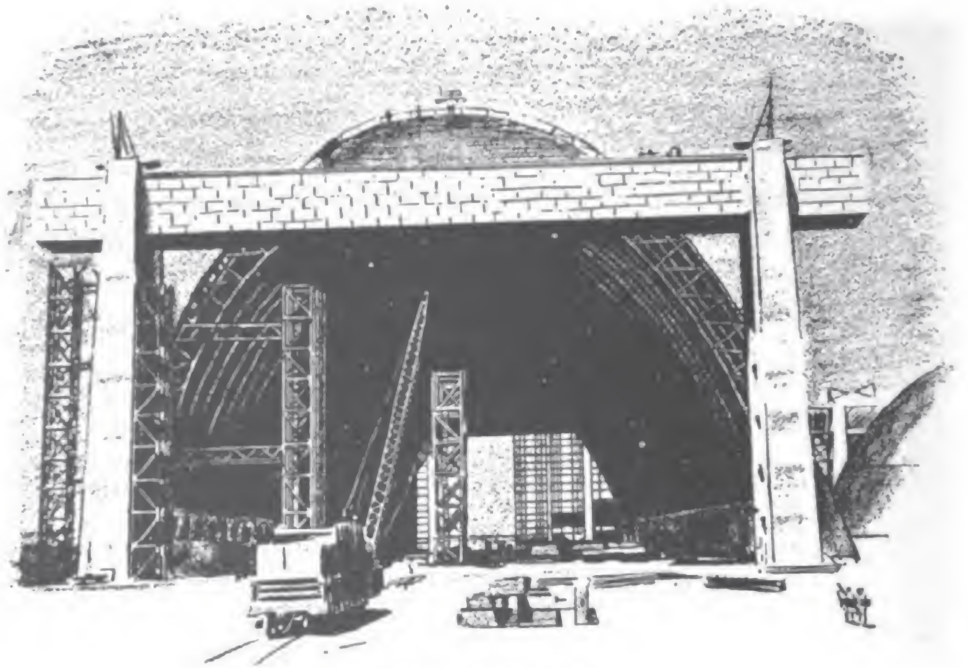


Figure 14-50.—Use of welding symbols on structural drawing.

QUIZ

1. Which contains more information, the *weld symbol* or the *welding symbol?*
2. Are there weld symbols for brazing, forge, thermit, induction, and flow welding? What is used?
3. If the weld is to be on the side of the joint toward the arrow, where should the weld symbol be placed?
4. Draw the weld symbols for the following:

a. Bead	d. Spot
b. Slot	e. Seam
c. Square	f. Fillet



CHAPTER 15

ARCHITECTURAL AND STRUCTURAL DRAWINGS

ARCHITECTURAL WORKING DRAWINGS

Architectural drawings consist of preliminary studies, presentation drawings, and working drawings. In this book we consider only in brief some of the common aspects of working drawings. As a Navy man you won't be concerned with the design and sale of buildings; but as a technician using blueprints you may have cause to interpret and apply certain architectural conventions and symbols.

Working drawings include PLANS, ELEVATIONS, SECTIONS, DETAIL DRAWINGS, and SPECIAL FEATURES.

PLANS.—The SITE PLAN gives the salient features of a building site, the property line, contours, utilities (water, gas, sewer, electricity), location of trees, and other features. A FLOOR PLAN is a horizontal section which not only shows the floor but cuts across the walls in such a way as to show the doors, windows, partition walls, beams, out-

lets, and many similar installations. It might be said that a floor plan shows everything between one floor and the next one.

ELEVATIONS.—An elevation shows the front, side or rear view of a structure. It is a vertical projection and gives the floor heights, openings, and the exterior features of the building.

SECTIONS.—Sections are interior views, used to show interior construction and architectural treatment.

DETAIL DRAWINGS.—Detail drawings are, as the name implies, larger-scale drawings illustrating the detailed construction of the various parts of a structure.

SPECIAL FEATURES.—Many parts used in building construction are manufactured as unit pieces by specialized firms. For example, ventilating fans, stock stairs, and railings come in certain sizes and designs. When these are used in a building, the architect draws his plans to allow for the stock sizes and designs. Then the blueprints provided by the manufacturer are used in connection with such special equipment.

ARCHITECTURAL SYMBOLS

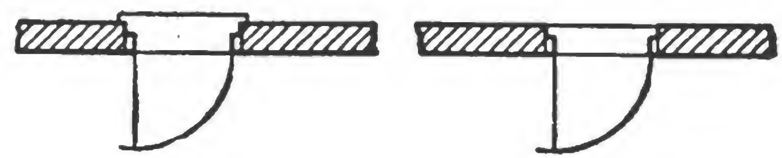
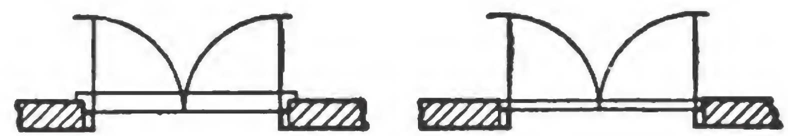
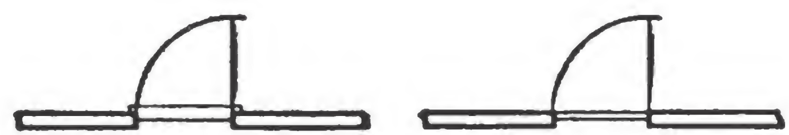
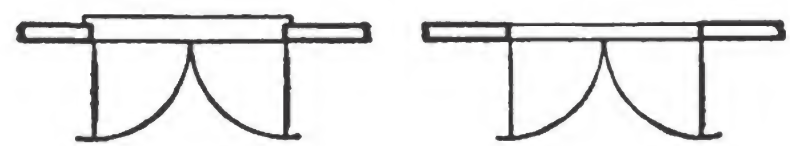
For the most part, the same electrical, mechanical, and piping symbols described or referenced in the earlier chapters of this book are used in architectural prints. Here some of the specific architectural symbols agreed on for combined military use are shown; and at the end of this chapter some of the materials symbols, also approved for use by the Armed Forces, are illustrated.

STRUCTURAL DRAWINGS

Structural drawings usually consist of some or all of the following elements:

GENERAL PLAN.—The general plan locates and gives the general features of the structure and the ground upon which it is situated. It includes the necessary data for designing the substructure and superstructure.

DOOR SYMBOLS

Type	*Symbol*
Single-swing with threshold in exterior masonry wall Single door, opening in	
Double door, opening out	
Single door, opening out	
Double door, opening in	

Refrigerator door

Sliding doors

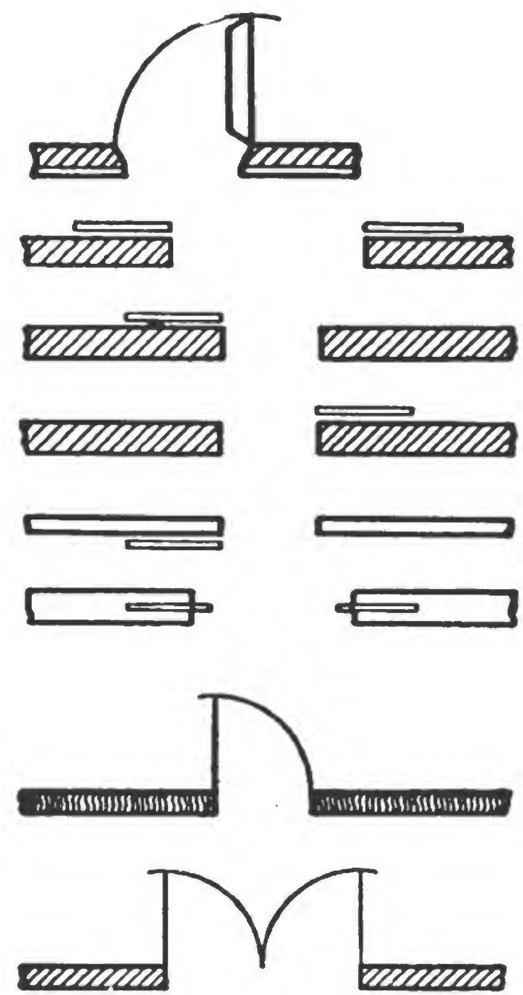
In masonry walls

In frame walls

Single-swing, in interior masonry partition

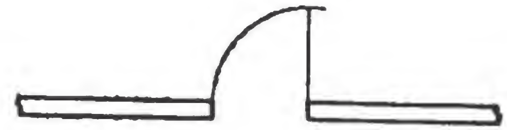
Single door

Double door



Single-swing, in interior frame partition

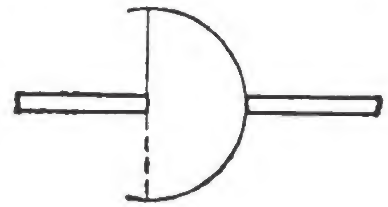
Single door



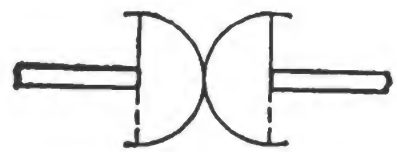
Double door

Double-acting doors

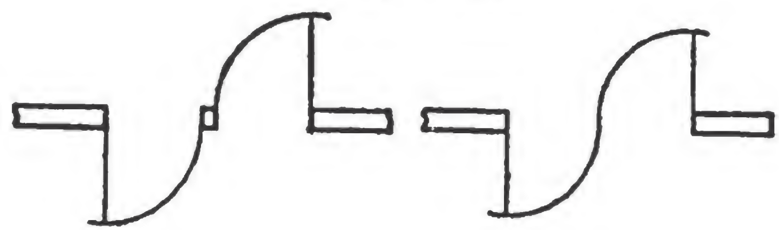
Single door



Double door

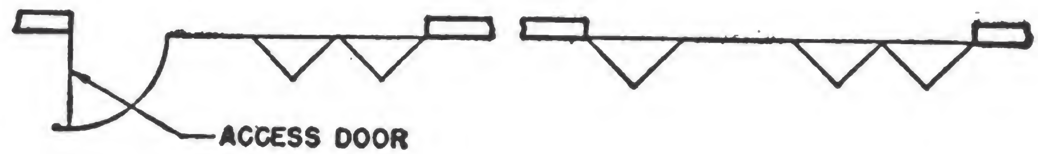


In and out doors

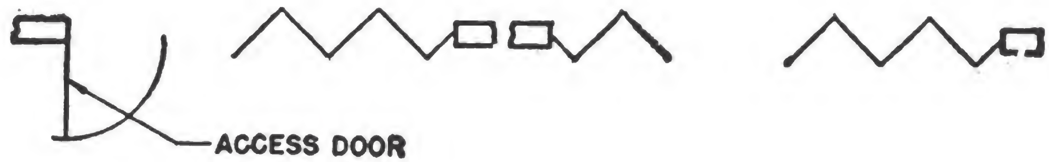


Folding door or folding partition

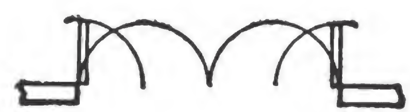
End hung



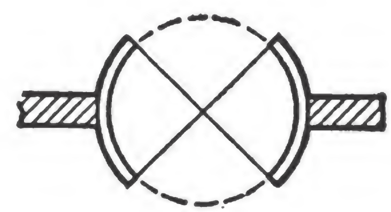
Center hung



Double-leaf door



Revolving door



WINDOW SYMBOLS

Windows in plan

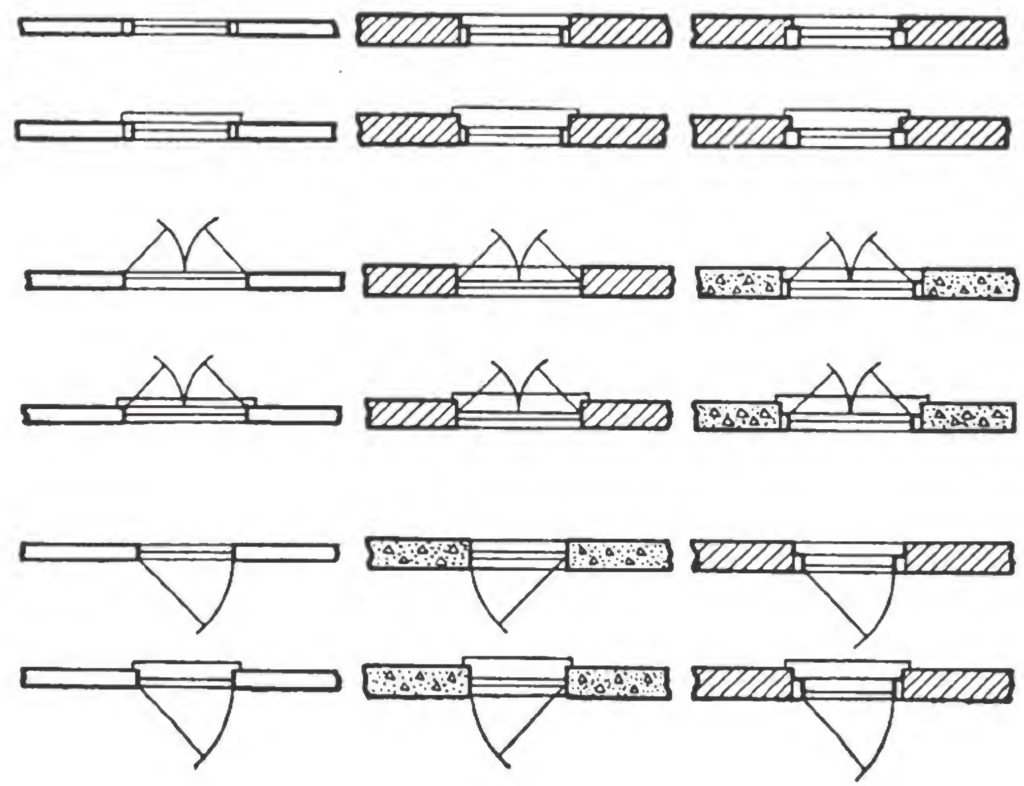
Type	*Symbol*: *Wood or metal sash in frame wall*	*Metal sash in masonry wall*	*Wood sash in masonry wall*

Double hung

Casement

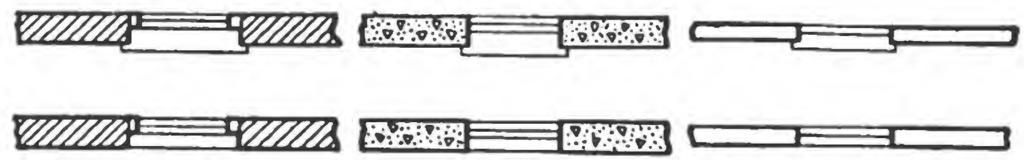
Double, opening out

Single, opening in

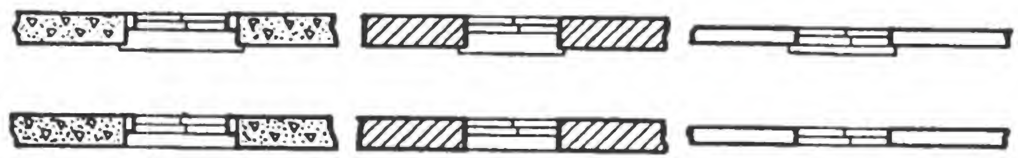


Horizontal-sliding sash

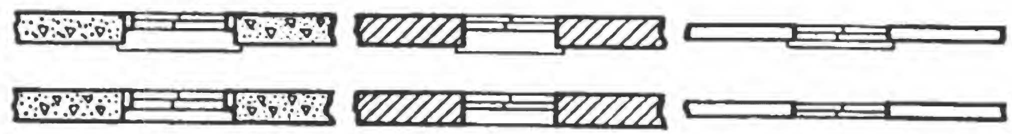
Right sash over left



Left sash over right



Pivoted and vented (Indicate pivoting and direction of venting on elevation.)

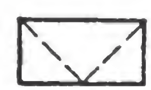


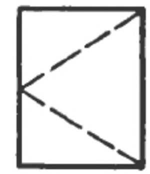
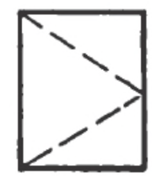
Venting of windows in elevation

Type — *Symbol*

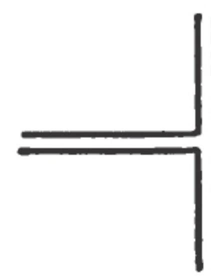
Top hinged, projected out

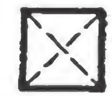
Bottom hinged, projected in



Pivoted, horizontal	
Hinged, left side	
Hinged, right side	

MISCELLANEOUS SYMBOLS

Item	*Symbol*
Stud partition, unless otherwise noted.	

Elevators, hatchways, openings in floor, ducts, etc.	
Louvered openings in masonry wall	
Wood louver	
Metal louver	
Louvered opening in frame wall	

STRESS DIAGRAM.—The stress diagram shows the main dimensions, the loadings, stresses, and sizes of the members of the structure.

SHOP DRAWING.—A shop or detail drawing shows the details of the steel-and-iron work and of the timber, masonry, and concrete work.

FOUNDATION OR MASONRY PLAN.—The foundation or masonry plan covers the detail of the foundations, walls, piers, etc.

ERECTION DIAGRAM.—The erection diagram identifies and locates the various members in such a way as to help the erector in the field. For example, the approximate weight of the heavy pieces, the shipping marks, the number of pieces, and any other helpful data will be supplied on the erection diagram.

FALSEWORK PLAN.—For difficult or important work, plans for falsework, travelers, derricks, etc., may be worked out and supplied in advance.

BILLS OF MATERIAL.—Bills of material show the different parts of the structure, markings, and shipping weight. These bills serve as check-off lists to insure that the proper materials are on hand.

RIVET LIST.—The rivet list provides the dimensions and the number of the rivets, spikes, etc., used in the structure.

LIST OF DRAWINGS.—Since so many drawings are required for any sort of sizable structure, the drawings on pages *218* to *237* are provided to show the contents of all drawings belonging to the structure.

The remainder of the chapter includes illustrations of symbols used in specific types of construction.

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SYMBOLS FOR GENERAL USE

Description	*Symbol*	*Illustrated use*
Tensile stress in a member	+	+59,000
Compressive stress in a member	−	−64,000
Pounds	#	120,000#
Kip (1000#)	K	30K
Feet	'	3'-6"
Inches	"	
Angular measurements		
Degrees	°	12° 36' 50"
Minutes	'	
Seconds	"	
Deflection	Δ	Δ = 0.300"
Modulus of elasticity	E	E = 30,000,000
At	@	4@6

Percent	%	20%
By	X	3X10
Round	ϕ	$1\frac{1}{2}\phi$
Square	$\square$	$2\square$
Structural framing, member designations (Followed by member number, and preceded by floor designation* where applicable)		
Beam	B	2B2
Girder	G	BG4
Joist	J	RJ6
Slab	S	4S8
Column	C	C10
Bracing	Br	Br12
Strut	St	St3

*Floor designation by number, with B for basement and R for roof.

Footing	F	F5
Girt	Gt	Gt7
Knee brace	KB	KB9
Lintel	L	L11
Purlin	P	P2
Rafter	R	R4
Stair stringer	SS	SS6
Truss	T	T8
Wall	W	W10

REINFORCED CONCRETE CONSTRUCTION

The following symbols are for use on drawings of reinforced concrete structures or elements thereof.

Description	*Symbol*
Bars, round or square*	
Straight bars	
Plain ends	———

*For bar designation the symbols for round and square need not be used except in those cases where the same size bars are made in both rounds and squares, as in the case of the one-inch bar. In most cases the inch symbol can also be omitted without confusion.

Hooked one end

Hooked both ends

Bent bars

Plain ends

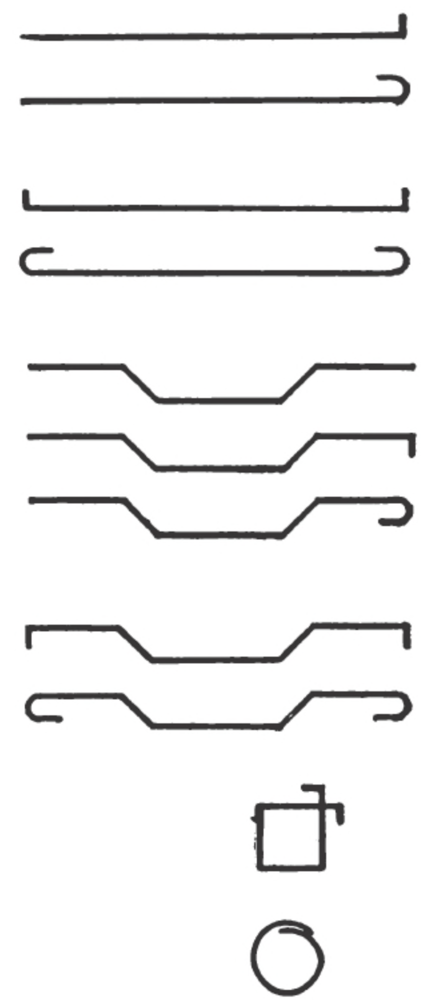
Hooked one end

Hooked both ends

Column ties

Square or rectangular

Circular

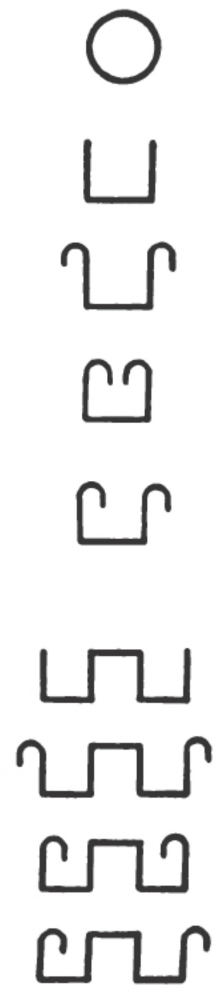


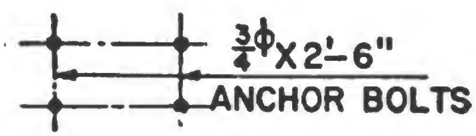
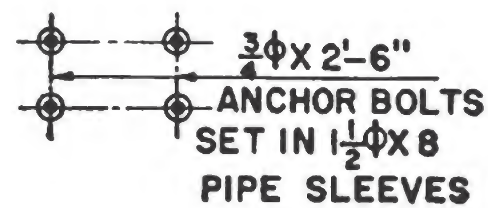
Column spiral

Stirrup

"U" type

"W" type



Description	*Symbol*	*Illustrated use*
Tied type		
Direction in which main bars extend		
Limits of area covered by bars		
Anchor bolt (in plan)		
Anchor bolt set in pipe sleeve (in plan)		
Ultimate compressive strength of concrete	f'_c	f'_c = 3000 PSI
Tensile stress in reinforcement	f_s	f_s = 20,000 PSI

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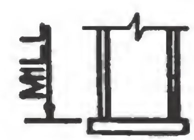
Compressive stress in concrete	f_c	f_c = 1050 PSI
Area of tensile reinforcement	A_s	A_s = 2.4 SQ IN.
Area of compressive reinforcement	A'_s	A'_s = 1.8 SQ IN.
Modulus of elasticity of concrete	E_c	E_c = 1,500,000 PSI
Modulus of elasticity of reinforcement steel	E_s	E_s = 30,000,000 PSI

STRUCTURAL STEEL AND ALUMINUM CONSTRUCTION

The following symbols are for use on drawings involving structural steel or aluminum construction. When both aluminum and structural steel shapes occur on the same drawing, add suffix "AL" to all aluminum shape designations; for example 8 ⊔ 6.67 AL.

Description	*Symbol*	*Illustrated use*
Gage	g	$g = 3\frac{1}{2}$
Pitch of rivets	P	$P = 2\frac{1}{2}$
Milled face	MILL	

Wide flange shape	WF	24WF76
Beams		
American standard	I	15I42.9
Light beams and joists	B	6B12
Standard mill	M	8M17
Junior	Jr	7Jr5.5
Light columns	M	8X8M34.3
Channels*		
American standard	⊔	9 ⊔ 13.4
Car and ship	⊔	12X4 ⊔ 44.5
Junior	Jr ⊔	10Jr ⊔ 8.4
Angles*		
Equal leg	L	L 3X3X$\frac{1}{4}$

*Symbols for channels and angles may be oriented to agree with the position of the member being designated.

	Unequal leg	L	L 7X4X$\frac{1}{2}$
	Bulb	BULB L	BULB L 6X3$\frac{1}{2}$X17.4
	Serrated (cut from channel)**	X	X (3+1) ⊔ 4.1
Tees			
	Structural, cut from rolled shapes	ST	ST 5 WF 10.5
			ST 6 I 20.4
			ST 6 B 9.5
			ST 6 Jr 5.90
	Rolled (flange by stem)	T	T 4X3X9.2
	Built up	T	T BAR 3X$\frac{1}{2}$ BAR 4X$\frac{1}{4}$
	Serrated (cut from beam)**	X	X (4+1) WF 10
Bearing pile		BP	14BP73

**In example given under illustrated use, the sum of the figures within the parentheses is the depth of the stem, the first figure being one-half the depth of the cut shape and the second being one-half the depth of serration.

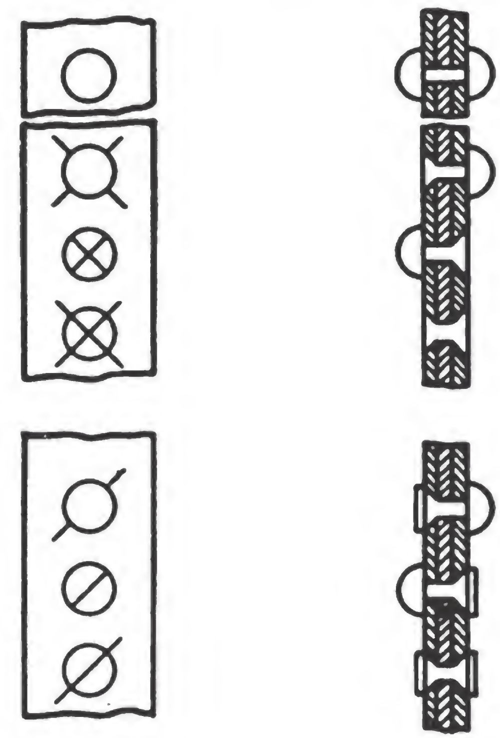
Zee	Z	Z6X$3\frac{1}{2}$X15.7
Plate	Pl	Pl 18X$\frac{1}{2}$X2'-6"
Plate (alternative use)	Pl	$10.2^{\#}$Pl
Checkered plate	CkPl .	CkPl $\frac{1}{2}$
Flat bar	Bar	Bar $2\frac{1}{2}$X$\frac{1}{4}$
Tie rod	TR	$\frac{3}{4}^{\phi}$ TR
Pipe column	O	O6^{ϕ}

COMBINATIONS OF STRUCTURAL SHAPES

Except for those shapes for which the symbol is a letter or letters, symbols for single structural shapes may be combined to indicate the composition of a built up member. For instance a double-angle strut may be represented thus ┐┌ ;and a channel and angle section may be represented by]┌ Where a combination includes a shape the symbol for which is a letter or letters, a line representation of the shape may be used, as for instance in the case of a wide flange beam and a channel, the representation may be thus Ɪ . The representation in each case may be accompanied by the sizes of the shapes, involved, thus Ɪ 24 WF 100 2 Pl 14 X $\frac{3}{4}$.

RIVETING SYMBOLS

Description	*Symbol*
Shop rivets	*Plan* / *Section*
Two full heads	
Countersunk & chipped NS[1]	
Countersunk & chipped FS[2]	
Countersunk & chipped BS[3]	
Countersunk, not over $\frac{1}{8}$ inch high NS	
Countersunk, not over $\frac{1}{8}$ inch high FS	
Countersunk, not over $\frac{1}{8}$ inch high BS	

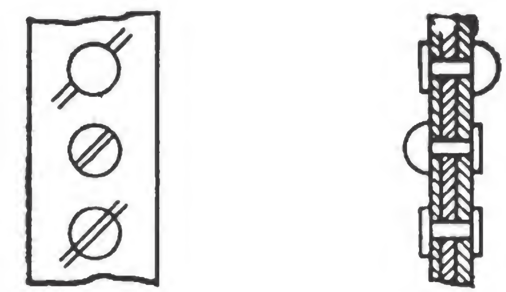


[1]NS-near side. [2]FS-far side. [3]BS-both sides.

Flattened to $\frac{1}{4}$ inch for $\frac{1}{2}$ and $\frac{5}{8}$ rivets NS

Flattened to $\frac{1}{4}$ inch for $\frac{1}{2}$ and $\frac{5}{8}$ rivets FS

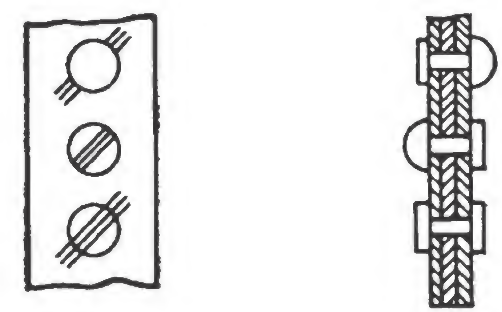
Flattened to $\frac{1}{4}$ inch for $\frac{1}{2}$ and $\frac{5}{8}$ rivets BS



Flattened to $\frac{3}{8}$ inch for $\frac{3}{4}$ and over rivets NS

Flattened to $\frac{3}{8}$ inch for $\frac{3}{4}$ and over rivets FS

Flattened to $\frac{3}{8}$ inch for $\frac{3}{4}$ and over rivets BS



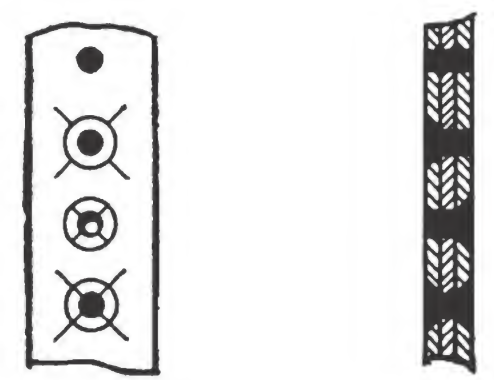
Field rivets

Two full heads

Countersunk NS

Countersunk FS

Countersunk BS



TIMBER CONSTRUCTION

The following symbols are for use on drawings involving timber construction.

Description	*Symbol*	*Illustrated use*
Horizontal shearing stress	H	H=120PSI
Compressive stress perpendicular to grain	$c\perp$	$c\perp$=455PSI
Compressive stress parallel to grain	c	c=1450PSI
Stress in extreme fibre for bending	f	f=1450PSI
Tensile stress parallel to grain	t	t=1450PSI

TIMBER CONNECTORS

Split ring	SR	$2\frac{1}{2}$SR
Toothed ring	TR	2TR

Claw plate; male	CPM	$2\frac{5}{8}$ CPM
Claw plate; female	CPF	$3\frac{1}{8}$ CPF
Shear plate	SP	4SP
Bulldog; round	BR	$3\frac{3}{4}$ BR
Bulldog; square	BS	5BS
Circular spike	CS	$3\frac{1}{8}$ CS
Clamping plate; plain	CPP	5X5CPP
Clamping plate; flanged	CPFL	5X8CPFL
Spike grid; flat	SGF	$4\frac{1}{8}$X$4\frac{1}{8}$ SGF
Spike grid; single curve	SGSC	$4\frac{1}{8}$X$4\frac{1}{8}$ SGSC
Spike grid; double curve	SGDC	$4\frac{1}{8}$X$4\frac{1}{8}$ SGDC

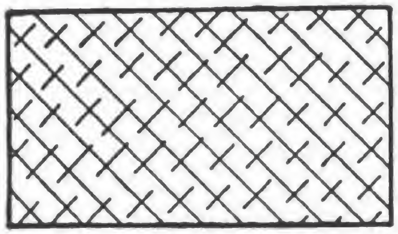
IDENTIFICATION OF TIMBERS FOR SPECIAL GRADING

Where special grading provisions must be used for certain members because of the design conditions, such members may be designated with the following symbols:

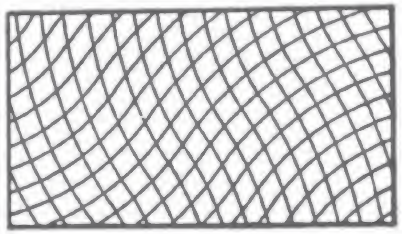
Description	*Symbol*
Joists and planks or beams and stringer grades	
Beams, continuous over 2 spans	**M**
Beams, continuous over 3 or more spans	**N**
Members in tension, or in compression parallel to grain, or in combined compression and bending	**T**
Post and timber grades	
Special size members not conforming to standard post and timber classification sizes	**P**

MATERIAL SYMBOLS

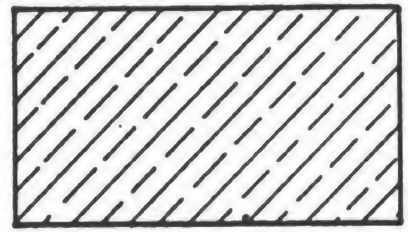
(See chapter 3, figure 3–10, for the simplified section conventions which are preferred wherever practicable.)



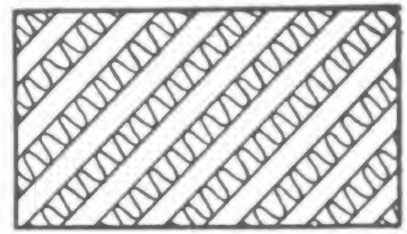
Aluminum, magnesium, and their alloys



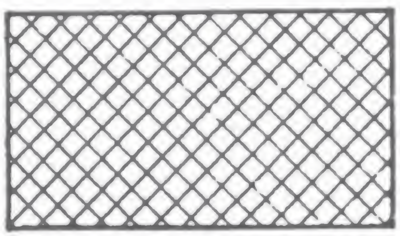
Asphalt



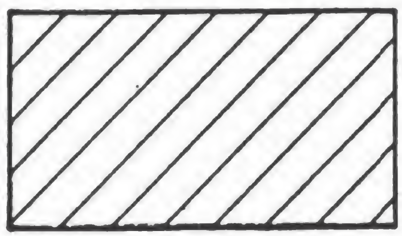
Copper, brass, bronze, and their compositions



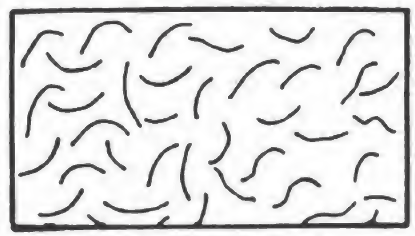
Asbestos, magnesia, filler packings, and similar materials



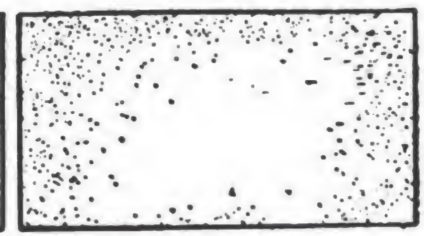
Babbitt, lead, solder, bearing metals and white metals



Brick

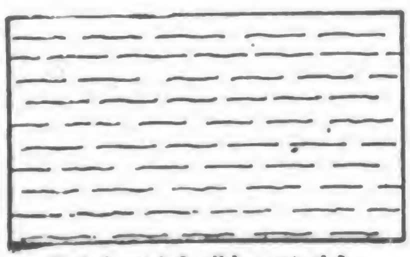


Felt and leather (natural)

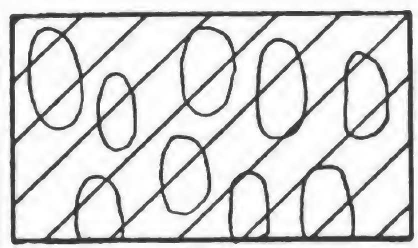


Cut stone

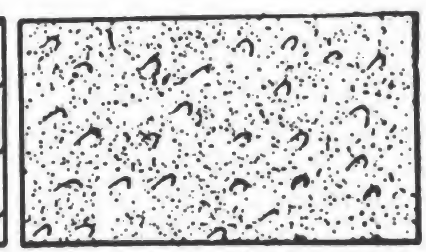
Coal



Fabric and flexible material



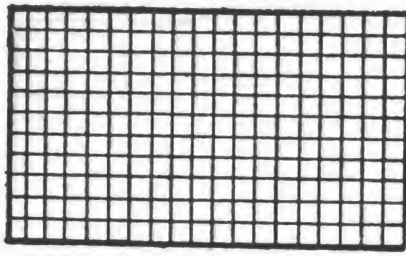
Cork



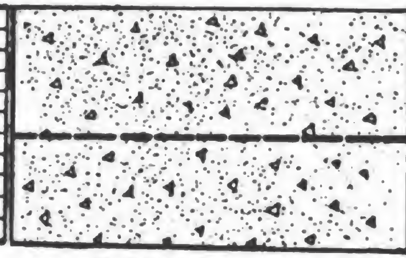
Cinder block

932348°—51——16

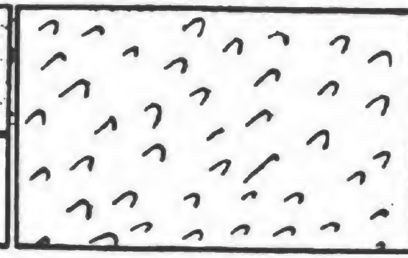
MATERIAL SYMBOLS (Continued)



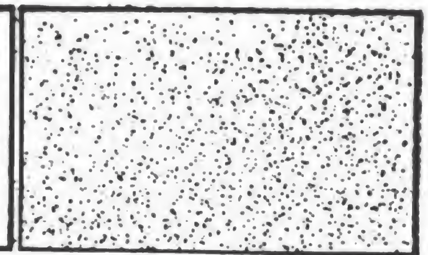
Electrical windings, electrical magnets and resistances, etc.



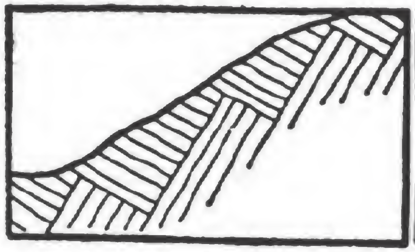
Reinforced concrete



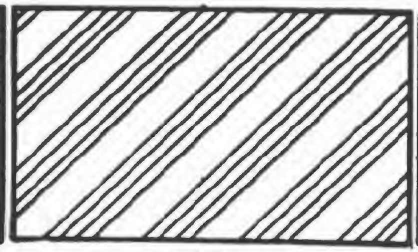
Cinders



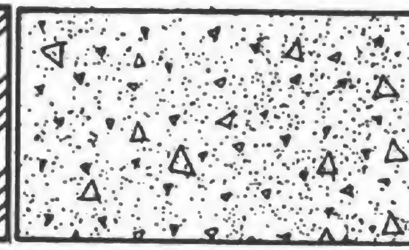
Cement and plaster



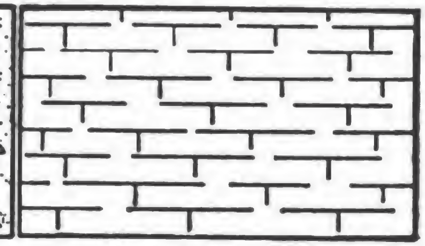
Earth



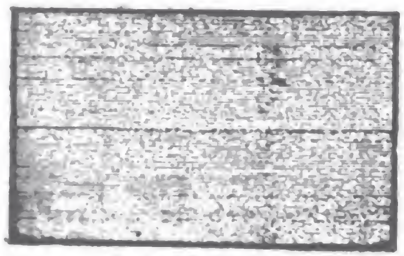
Electrical insulation



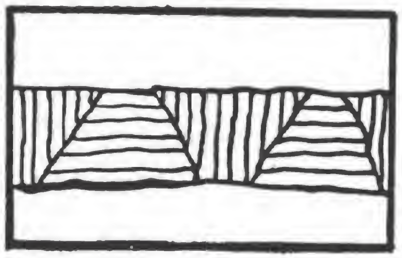
Concrete and concrete block



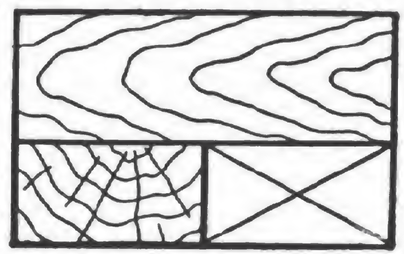
Chalk



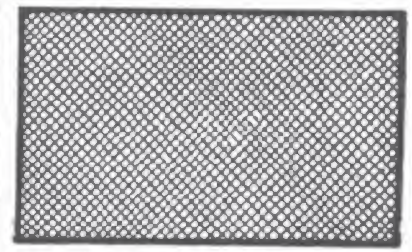
Container board



Rock

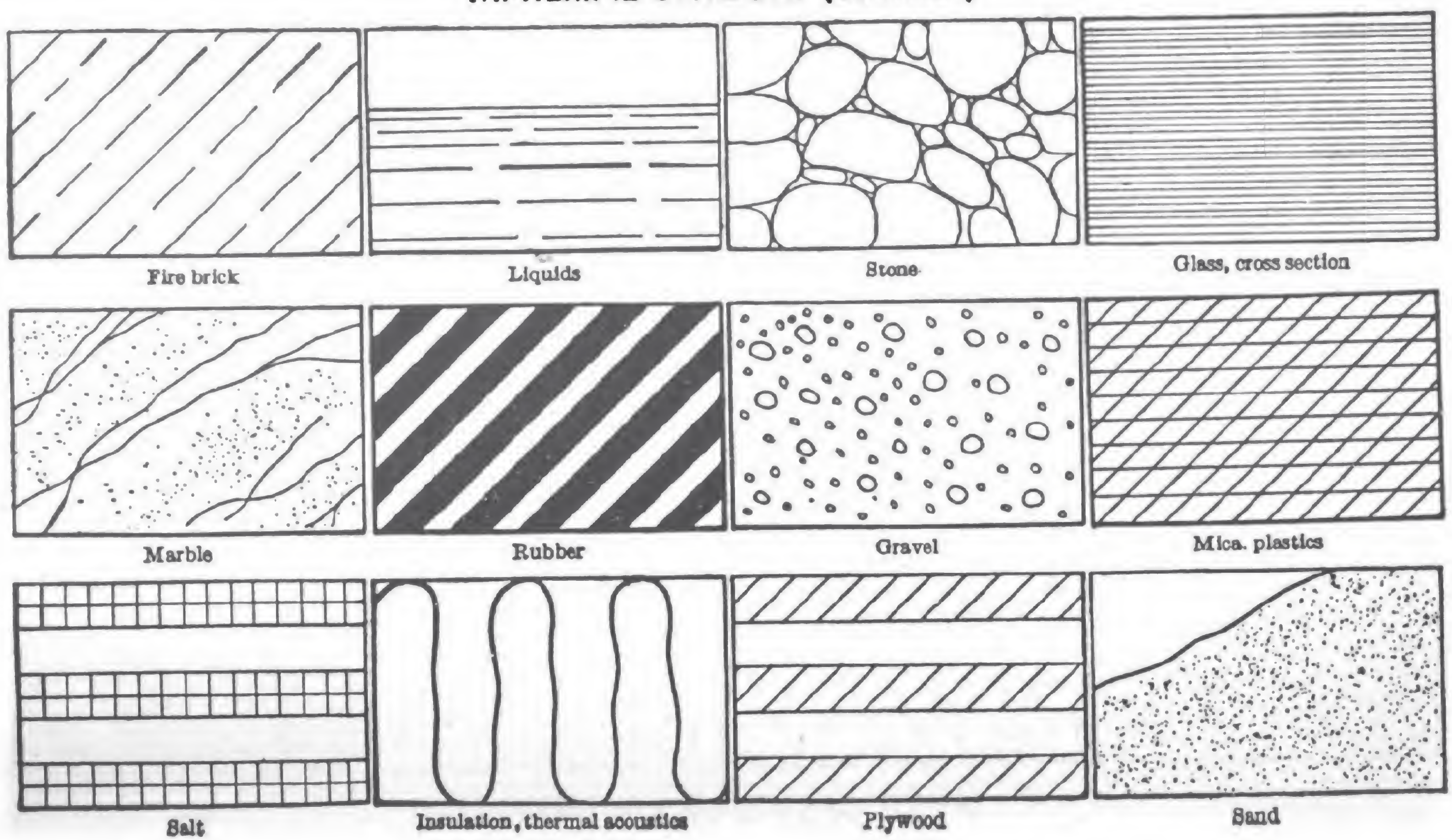


Wood: 1, with grain; 2, cross grain; 3, blocking

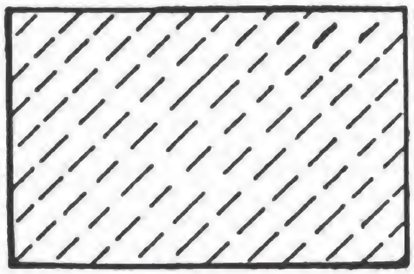


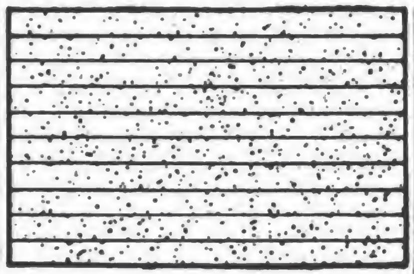
Composition and mastic

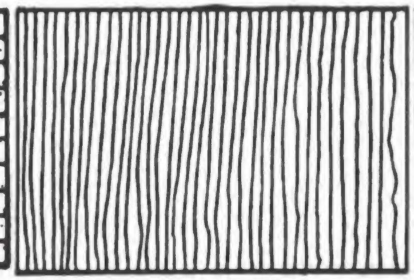
MATERIAL SYMBOLS (Continued)

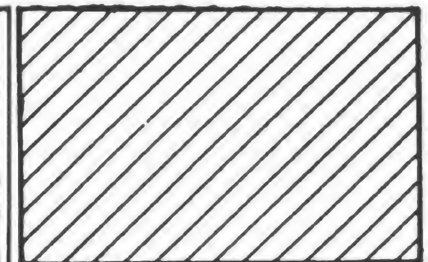


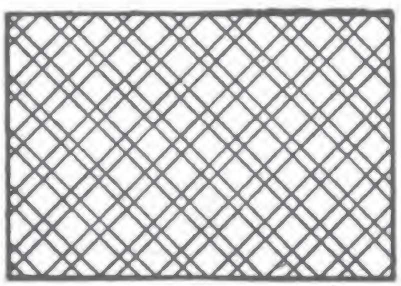
MATERIAL SYMBOLS (Continued)

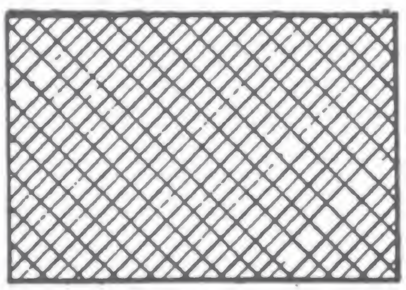

Porcelain

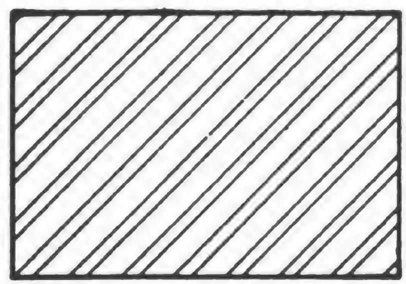

Slate

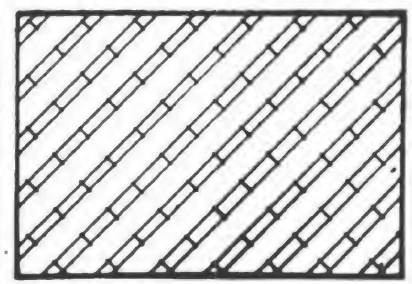

Tile, structural; ceramic, structural; facing, etc.


Iron, including cast iron, malleable iron

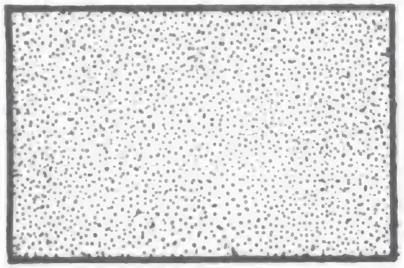

Zinc

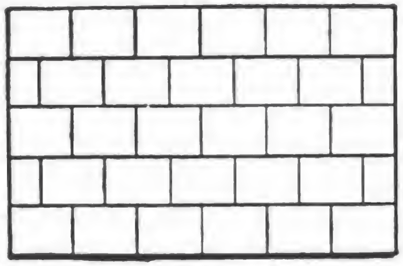

Tin

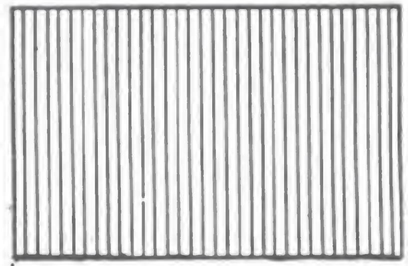

Steel and wrought iron

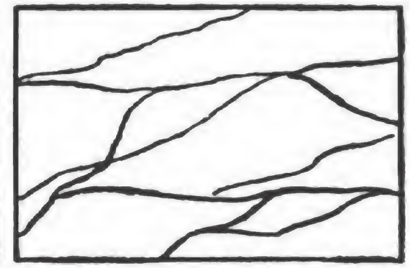

Special alloys

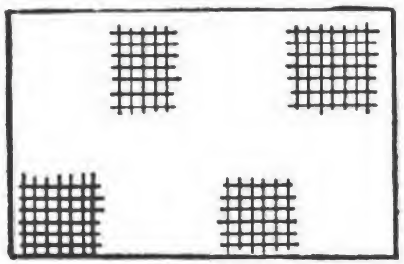
EXTERIOR MATERIAL SYMBOLS

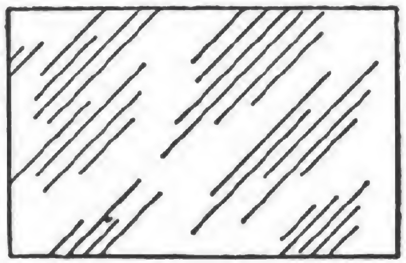

Concrete, stucco, plaster

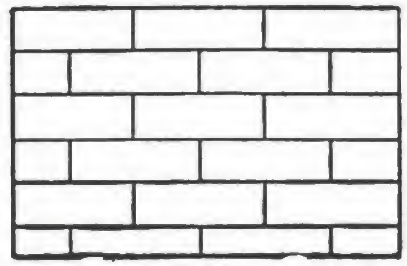

T C tile

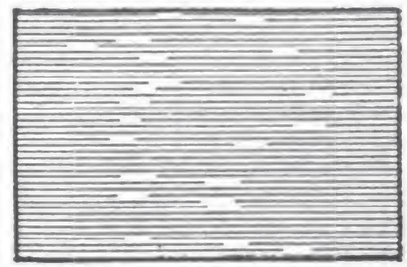

Roofing tile

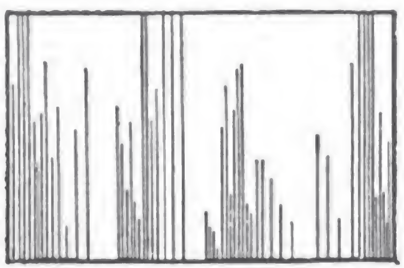

Marble

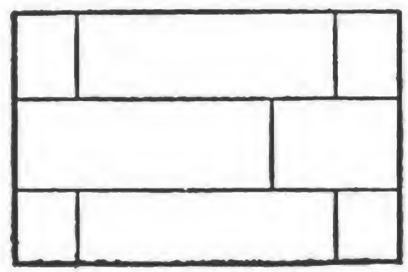

Wire mesh


Glass and transparent material


Brick


Brick, small scale


Metal


Concrete block, cinder block

QUIZ

1. Are the materials symbols shown in chapter 3 preferred to those shown in chapter 15?
2. What does a *site plan* show?
3. What is the symbol for a single double-acting door?
4. a. What is a *kip?* b. What is its symbol?
5. Give the symbols for the following:
   a. Pounds
   b. At
   c. By
   d. Field rivet with two full heads
   e. asphalt (section convention)
   f. Mica (section convention)
   g. Rubber (section convention)
   h. Special alloys (section convention)
   i. Plywood (section convention)

APPENDIX I

ANSWERS TO QUIZZES

CHAPTER 1

MAKING AND HANDLING BLUEPRINTS

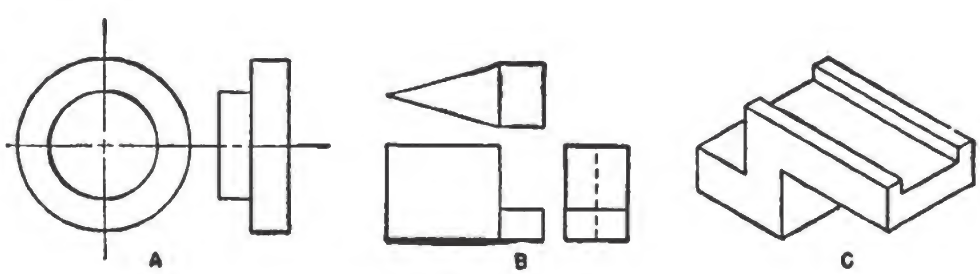
1. Unit assembly.
2. Protect them from dampness, grease, and strong sunlight.
3. Distance should never be measured on a blueprint, because of three possible sources of error:

   Original inaccuracy of draftsman's work.
   Stretching during the blueprinting process.
   Shrinking during the blueprinting process.

CHAPTER 2

BLUEPRINT VIEWS

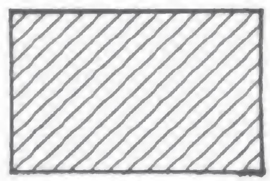
1. The photograph is not accurate. It does not show true shape or size.
2. Train views. The parts of an assembly or sub-assembly are spread out on the paper like cars on a railroad track.
3. The lines of the isometric representing the horizontal and vertical lines of the object are true in length.
4. Mechanical prospectives are used to provide pictures of objects not yet constructed.
5. They are accurate. The lines of orthographic projection views indicate the true size and shape of the object drawn.
6. An inclined or slant surface.
7.



CHAPTER 3

LINES AND SECTIONS

1. The names of the lines are:
   (1) Centerline.
   (2) Object outline.
   (3) Dimension line.
   (4) Extension line.
   (5) Hidden line.
2.



3. Revolved section.
4. Leader.

CHAPTER 4

DIMENSIONS

1. a. Because each dimension is measured from the preceding dimension, each measurement is thus influenced by the errors in preceding measurements, and the total error will exceed the sum of the individual errors. On a part having many location dimensions, many individual errors may be made, and a serious total error may accumulate.
   b. By measuring each dimension in turn from the same reference edge (or line).
   c. The double error in the last dimension measured, to which baseline dimensioning is always susceptible, will fall in whichever dimension the draftsman leaves open.
   d. Floating dimension.
2. a. Hole: 6.5046 inches.
   Shaft: 6.4913 inches.
   b. 0.0179 inch. (Maximum diameter hole 6.5046 inches—minimum diameter shaft 6.4867 inches.)
3. One and only one. It's your base point.

CHAPTER 5

TITLE BLOCKS, NUMBERS, AND BILLS OF MATERIAL

1. For identification during assembly and to speed up replacement of broken parts.
2. a. That the blueprint represents a fuselage ring which would be located, on an airplane, 209½ inches from zero station (nose or firewall).

   b. If a zone number for this part were shown in the title block, the desired view would be found in the general area marked by the corresponding zone number in a square along the lower border line of the blueprint.
3. In the stock size column of the title block.
4. By a letter, in a small circle near some dimension or note, or in a separate change or revision block.

CHAPTER 6

LAYOUT TOOLS

1. a. *1.* Scriber.

   2. Straight edge.

   3. Machinist's steel rule.

   4. Dividers (or trammel).

   5. Prick punch.

   6. Square.

   7. Protractor.

   8. French curve.

   b. Straightedge: Do not bend or dent guide edges.

   Oil and store when not in use.

   Machinist's steel rule: Measure from 1" mark to save wear and tear on ends.

   Do not nick or scratch.

   Keep in oiled leather sheath to guard against rust and dirt.

   Dividers: Reduce wear on adjusting screw by grasping both legs between thumb and finger when turning screw.

Prick punch: Use guiding wheel and oilstone to keep points sharp and properly angled.

2. Because the work of lofting (laying out large parts to actual size) requires tools capable of transferring large distances.

CHAPTER 7

LAYOUT GEOMETRY

1. Check your constructions against figures 7-8, 7-6, 7-3, 7-4, and 7-7.
2. a. Nine steps.
   b. 1.7 inches ($1° =$ Circumference $67.54 \div 360$).

CHAPTER 8

LAYING OUT

1. The stock should have one squared edge and one squared end.
2. To provide a background against which your layout lines will show up clearly.
3. The reference line must be on the surface of the layout; the reference edge cannot be on the surface.
4. Basic centerline method.
5. Prick punch marks locate the centers of drilled holes and provide pivot points for swinging arcs.
6. Scratches may penetrate a protective coating and expose the metal to corrosion, or they may focus stresses and lead to early failure of the piece.

CHAPTER 9

CURVE OR BEND ALLOWANCE

1. a. Bend Allowance Table.
   b. Set Back Development Chart.
2. a. Closed; 80°.
   b. Open; 89°.
   c. Open; 35°.
   d. Neither closed nor open.
3. The unbent surfaces of a curved corner.

CHAPTER 10

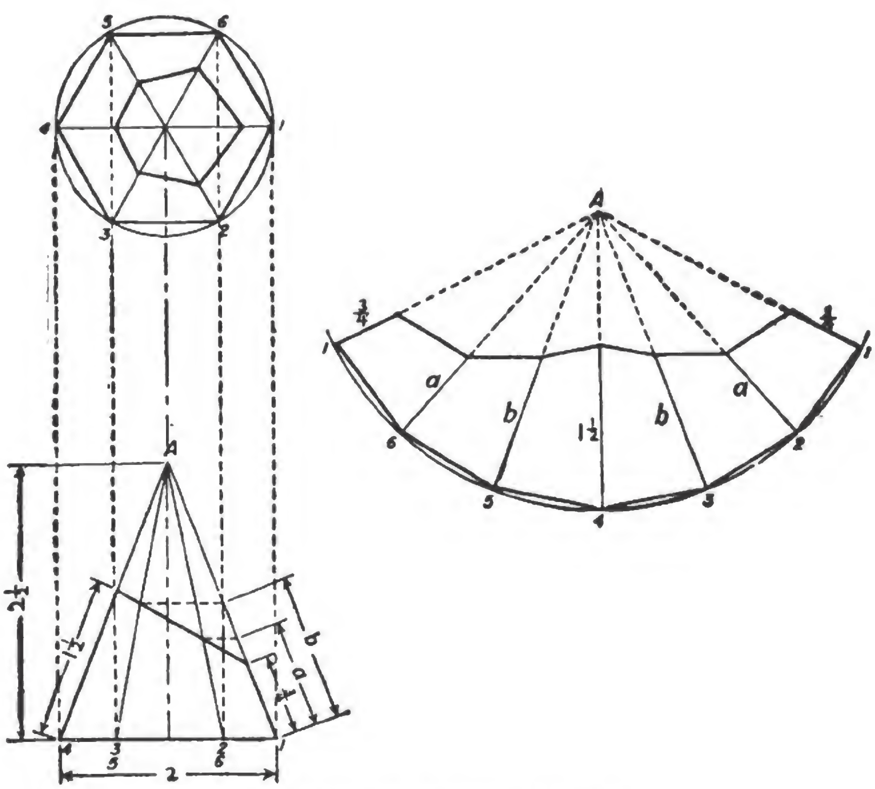
TEMPLATES

1. The strain on metal caused by the intersection of two or more bends.
2. a. Because the accuracy of all the parts made from a template as pattern will depend upon the accuracy of the template.
   b. Use scribers and dividers instead of pencil or pencil compass for all outlines except those not to be cut.
   Check transferred dimensions, divider settings, and scribed lines with magnifying glass.
   Punch holes to specify location rather than size.
3. Make a new template from the blueprint.

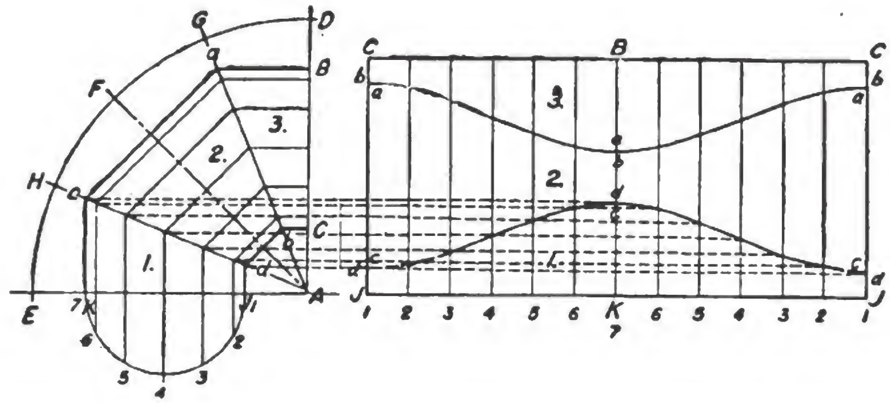
CHAPTER 11

DEVELOPMENTS

1.



Check your method against pages 122–127.



KJ diameter of semicircle is diameter of elbow cylinder.

Semicircle is divided into six equal parts.

Length of stretch-out (JJ) is computed circumference of the circle having KJ diameter.

Height of stretch-out (JC) is sum of Jd, ca bC.

Lower outline on stretch-out is made by parallel development.

Upper outline may be transferred from lower by dividers, but in practice lower outline will be used as template for upper.

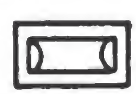
Check your method against pages 121–122.

CHAPTER 12

ELECTRICAL BLUEPRINTS

1. Wiring diagrams, schematic diagrams.
2. a. No.
   b. Schematic.
3. In construction.
4. *1.* By a half circle, or loop:
   2. When dots are used to show a connection,
   then no dot means no connection:
5. The outer lines of the symbols are doubled:

Nonwatertight.

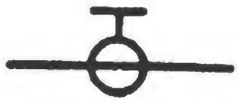


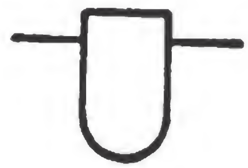
Watertight.

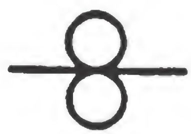
CHAPTER 13

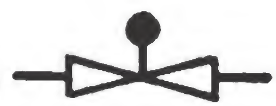
MECHANICAL AND PIPING SYMBOLS

1. No.
2. a. The pitch or number of gear teeth per inch.
   b. The number of teeth on a gear.
3.

a. 

c. 

b. 

d. 

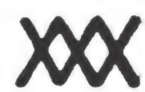
CHAPTER 14

WELDING SYMBOLS

1. The welding symbol. It contains the weld symbol and up to seven more elements of information.
2. No. The tail of the welding symbol contains the necessary process or specification reference.
3. On the side of the reference line toward the reader.
4.

a. 

c. 

e. 

b. 

d. 

f. 

CHAPTER 15

ARCHITECTURAL AND STRUCTURAL DRAWINGS

1. Yes. The comprehensive symbols shown in chapter 15 are used only when necessary.

2. The salient features of a building site, the property line, contours, utilities, trees, etc.

3.

4. a. 1000 pounds.

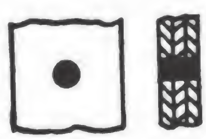
   b. K.

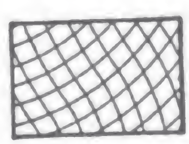
5.

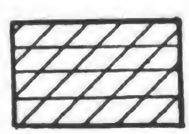
a. #

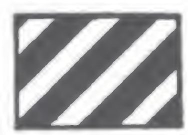
b. @

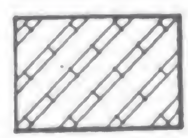
c. X

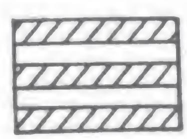
d. 

e. 

f. 

g. 

h. 

i. 

APPENDIX II

FRACTIONS AND DECIMAL EQUIVALENTS

1/64	.015625
1/32	.03125
3/64	.046875
1/16	.0625
5/64	.078125
3/32	.09375
7/64	.109375
1/8	.125
9/64	.140625
5/32	.15625
11/64	.171875
3/16	.1875
13/64	.203125
7/32	.21875
15/64	.234375
1/4	.25
17/64	.265625
9/32	.28125
19/64	.296875
5/16	.3125
21/64	.328125
11/32	.34375
23/64	.359375
3/8	.375
25/64	.390625
13/32	.40625
27/64	.421875
7/16	.4375
29/64	.453125
15/32	.46875
31/64	.484375
1/2	.5
33/64	.515625
17/32	.53125
35/64	.546875
9/16	.5625
37/64	.578125
19/32	.59375
39/64	.609375
5/8	.625
41/64	.640625
21/32	.65625
43/64	.671875
11/16	.6875
45/64	.703125
23/32	.71875
47/64	.734375
3/4	.75
49/64	.765625
25/32	.78125
51/64	.796875
13/16	.8125
53/64	.828125
27/32	.84375
55/64	.859375
7/8	.875
57/64	.890625
29/32	.90625
59/64	.921875
15/16	.9375
61/64	.953125
31/32	.96875
63/64	.984375
1	1.

APPENDIX III

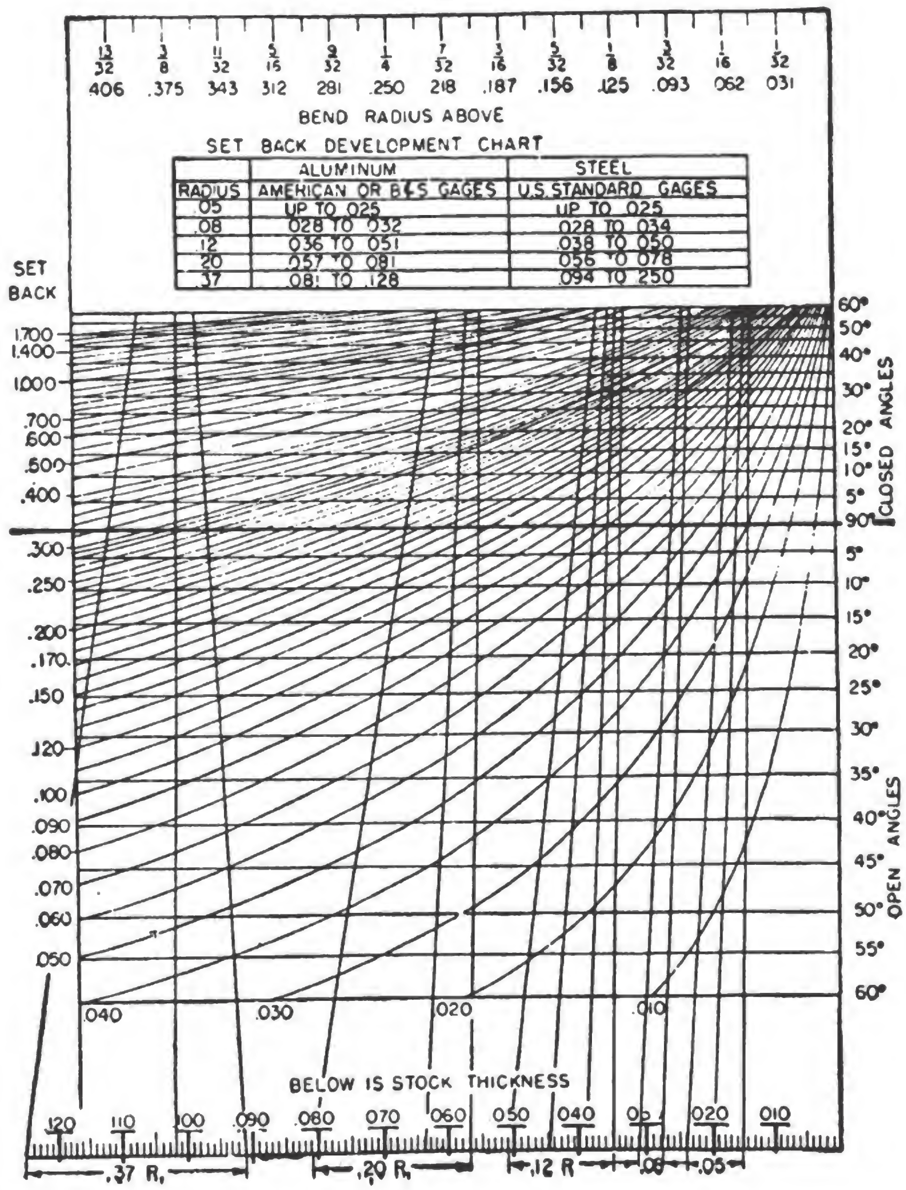
SHEET METAL BEND ALLOWANCE PER DEGREE OF BEND

Aluminum Alloys

Bend radius	Stock thickness							
	0.022	0.032	0.040	0.051	0.064	0.091	0.128	0.187
	Bend allowance per 1°							
1/32	0.00072	0.00079	0.00086	0.00094	0.00104	0.00125	0.00154	0.00200
1/16	.00126	.00135	.00140	.00149	.00159	.00180	.00209	.00255
3/32	.00180	.00188	.00195	.00203	.00213	.00234	.00263	.00309
1/8	.00235	.00243	.00249	.00258	.00268	.00289	.00317	.00364
5/32	.00290	.00297	.00304	.00312	.00322	.00343	.00372	.00418
3/16	.00344	.00352	.00358	.00367	.00377	.00398	.00426	.00473
7/32	.00398	.00406	.00412	.00421	.00431	.00452	.00481	.00527
1/4	.00454	.00461	.00467	.00476	.00486	.00507	.00535	.00582
9/32	.00507	.00515	.00521	.00530	.00540	.00561	.00590	.00636
5/16	.00562	.00570	.00576	.00584	.00595	.00616	.00644	.00691
11/32	.00616	.00624	.00630	.00639	.00649	.00670	.00699	.00745
3/8	.00671	.00679	.00685	.00693	.00704	.00725	.00753	.00800
13/32	00725	.00733	.00739	.00748	.00758	.00779	.00808	.00854
7/16	.00780	.00787	.00794	.00802	.00812	.00834	.00862	.00908
15/32	.00834	.00842	.00848	00857	.00867	.00888	.00917	.00963
1/2	.00889	.00896	.00903	.00911	.00921	.00943	.00971	.01017
17/32	.00943	.00951	.00957	.00966	.00976	.00997	.01025	.01072
9/16	.00998	.01005	.01012	.01020	.01030	.01051	.01080	.01126
19/32	.01051	.01058	.01065	.01073	.01083	.01105	.01133	.01179
5/8	.01107	.01114	.01121	.01129	.01139	.01160	.01189	.01235
21/32	.01161	.01170	.01175	.01183	.01193	.01214	.01245	.01289
11/16	.01216	.01223	.01230	.01238	.01248	.01268	.01298	.01344
23/32	.01269	.01276	.01283	.01291	.01301	.01322	.01351	.01397
3/4	.01324	.01332	.01338	.01347	.01357	.01378	.01407	.01453

APPENDIX IV

SET BACK DEVELOPMENT CHART



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